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ECONOMIC DEPRESSION IN WELSH FARMING.

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Amongst the farms for which accounts have been kept over a number of years[1] there are twenty-nine which show practically no change except those in internal management and financial results and these therefore provide fairly accurate information on the incidence of the economic depression. A farmer here has added a field and another released a small area but the variations in total acreage from year to year are less than one per cent. and no single farm shows a marked change. The total area covered by these farms together with the total land under arable crops and the rent per acre is as follows :

	1930-1.	*1931-2.*	*1932-3.*	*1933-4.*
Total acres	4,554	4,558	4,588	4,599
Total arable	380	341	366	356
% Arable to total	8.3	7.5	8.0	7.7
Rent per acre	12s. 6d.	12s. 5d.	12s. 8d.	12s. 5d.

The average size of the farms at about 157 acres is considerably above the average size of farms in Wales, but a comparison of the utilisation of the land and the numbers of stock carried with the figures relating to the whole of Wales as shown by the Ministry of Agriculture *Statistics* for 1931 and 1933 indicates that these farms are fairly representative of Welsh farming conditions.

Land Utilisation.

The average size of the farms and the distribution of the crops in each year together with comparative data for the whole of Wales in 1931 and 1933 are given in Table I.

The greater part of the land is under grass and the area under crops does not exceed 8 per cent. of the total area in any year. Crop production is mainly for the maintenance of livestock and including the sale of small quantities of grain and potatoes the revenue from crops is of minor importance. Not only have these farms maintained approximately the same area of land but the proportion of arable to grass land remains

[1] By Department of Agricultural Economics, U.C.W., Aberystwyth.

TABLE I.

Land Utilisation.

	Per 100 Acres.				Per 100 acres (Wales)*	
	1930-1.	*1931-2.*	*1932-3.*	*1933-4.*	*1931.*	*1933.*
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Corn	6.69	6.03	6.16	6.34	5.34	5.34
Other crops	1.69	1.56	1.79	1.41	2.21	2.17
Total arable	8.38	7.59	7.95	7.75	7.55	7.51
Hay	13.82	14.30	14.13	13.98	17.78	17.67
Pasture	43.34	42.80	40.73	40.32	36.23	36.20
Rough grazing	34.46	35.31	37.19	37.95	38.44	38.62
Total pasture	91.62	92.41	92.05	92.25	92.45	92.49
Total acres	100.00	100.00	100.00	100.00	100.00	100.00
Wheat	0.55	0.49	0.72	0.65	0.35	0.48
Barley	1.31	1.38	1.17	1.08	0.80	0.68
Oats	3.94	3.38	3.91	3.93	3.71	3.71
Mixed corn	0.89	0.78	0.36	0.68	0.48	0.47
Potatoes	0.45	0.48	0.47	0.46	0.46	0.48
Sugar beet	0.09	—	—	—	0.01	0.03
Turnips and swedes	0.66	0.59	0.66	0.43	0.88	0.87
Mangolds	0.26	0.20	0.18	0.17	0.23	0.21
Rape and kale	0.23	0.22	0.46	0.25	0.28	0.26
Other crops	—	0.07	0.02	0.10	0.35	0.32

* Ministry of *Agriculture Statistics*, Part I, 1931 and 1933.

fairly constant over the whole period, and the variation is again less than one per cent. of the total. Some slight changes have taken place in the nature of the cropping. There has been a tendency to increase the acreage under wheat in the last two years and there has been a gradual decline of the area under barley. With the exception of the year 1931-2 when a slight reduction was shown oats have remained at about the same acreage. Mixed corn (usually oats and barley) declined in the first three years but some recovery in acreage was made in the fourth year. Taking all cereal crops together the variation between one year and another is very small indeed and only amounts on an average to about one acre per farm. Potatoes remain at about the same figure each year and over the whole period averaged about three-quarters of an acre per farm. Only in 1930-1 was any sugar beet grown and a total of four acres was recorded in that year. Of root crops, the growing of mangolds seems to be on the decline but this reduction is to some extent compensated by the increased area under rape and kale. Turnips and swedes show slight variations from year to year and in 1933-4 there was an appreciable reduction in the acreage grown; possibly a result of the dry season.

The acreage under corn is slightly higher than that recorded for Wales, but the total area under arable crops is similar, and the same general tendencies to increase or decrease the acreage under the different crops is common to both records. The percentage of the arable land in the different crops on these farms gives a better statement of their relative importance. These are given in Table II.

TABLE II.

Percentage Composition of Arable Crops.

Crop.	*1930-1.*	*1931-2.*	*1932-3.*	*1933-4.*
	%	%	%	%
Wheat	6.5	6.5	8.9	8.4
Barley	15.6	18.3	14.8	13.7
Oats	47.0	44.4	49.2	50.7
Mixed corn	10.8	10.3	4.5	8.8
Total corn	79.9	79.5	77.4	81.6
Potatoes	5.3	6.4	5.9	6.0
Sugar beet	1.0	—	—	—
Turnips and swedes	7.9	7.7	8.4	5.6
Mangolds	3.1	2.6	2.2	2.2
Rape and kale	2.8	2.9	5.8	3.3
Other crops	—	0.9	0.3	1.3
Total	100.0	100.0	100.0	100.0

As might be expected on farms where the growing of food for the maintenance of livestock is the primary object, oats occupies nearly 50 per cent. of the arable land. This is followed by barley which varies from 18.7 to 18.8 per cent. of the arable area. Mixed corn shows more fluctuation than any of the other cereal crops. In the first two years it represented nearly 11 per cent. of arable land, in the third year it dropped to 4.5 per cent. and rose in the fourth year to 8.8 per cent. In general, however, any increase or decrease in this crop is usually governed by the oat crop. Wheat is the least important of the cereal crops and in no year did it exceed 9 per cent. of the arable land. Approximately about 80 per cent. of the arable land in each year was devoted to cereals, the remainder being under roots of which potatoes and turnips and swedes were of major importance. The relative acreages under the different crops in each year remain fairly constant and this indicates that there has not been any great change in the cropping system on these farms over the whole period.

Livestock Carried.

For the purpose of showing the fluctuations in numbers and types from year to year and the density of the stocking the numbers of livestock carried are given in Table III. In addition some comparative figures for Wales are given for the years 1981 and 1988.

The figures are based on a monthly census of the livestock and for that reason give a fairly reliable record of the numbers maintained. Work and 'other' horses carried per farm show little change from one year to another. The lowest number of work horses is 2.6 per farm (1988-4) and the highest 2.8 per farm in 1980-1. Similarly with 'other horses' the highest is 1.8 (1982-8) and the lowest 1.5 per farm in 1980-1. Numbers of dairy cows have again kept fairly constant, the difference between the highest and lowest number over the four years is less than one cow per farm. On the other hand 'other cattle' show a tendency to increase in each year and the difference between the number carried in the first and in the fourth year is 1.5 per farm. Breeding ewes have increased steadily from 75.4 in 1980-1 to 88.8 per farm in 1988-4, or an increase of 18.4 breeding ewes per farm. While more prominence is given to the breeding flocks, the 'other sheep' show a tendency to decline in numbers: the decrease between 1980-1 and 1988-4 being 8.6 per farm. Breeding sows remain fairly constant and range between 1.7 and 1.4 per farm. Other pigs show wider

TABLE III.

Average number of livestock carried.

	Per 100 Acres.				*Per 100 acres (Wales)**	
	1930-1.	*1931-2.*	*1932-3.*	*1933-4.*	*1931.*	*1933.*
	No.	*No.*	*No.*	*No.*	*No.*	*No.*
Work horses	1.8	1.7	1.8	1.6	1.8	1.7
Other horses	1.0	1.1	1.1	1.0	1.0	1.0
Total horses	2.8	2.8	2.9	2.6	2.8	2.7
Dairy cows	5.9	5.7	5.6	6.1	6.8	7.1
Other cattle	12.0	12.4	12.7	12.9	11.5	12.1
Total cattle	17.9	18.1	18.3	19.0	18.3	19.2
Breeding ewes	48.0	53.5	54.6	56.0	43.9	45.4
Other sheep	38.7	41.5	37.6	34.8	52.6	51.1
Total sheep	86.7	95.0	92.2	90.8	96.5	96.5
Breeding sows	0.9	1.0	0.9	0.9	0.9	0.7
Other pigs	6.8	5.4	4.5	7.8	4.8	4.3
Total pigs	7.7	6.4	5.4	8.7	5.7	5.0
Laying flock	40.0	44.8	49.1	61.5	—	—
Other poultry	21.4	24.8	30.4	42.2	—	—
Total poultry	61.4	69.6	79.5	103.7	96.3	113.4
Total animal units (cows)	30.0	31.0	28.0	31.0	—	—

* Ministry of Agriculture Statistics Part I. 1931 and 1933.

differences and varied from 7.2 to 12.8 pigs per farm. Poultry stocks gradually increased in the first three years and there was a decided rise in the fourth year : the difference in the numbers carried between 1930-1 and 1933-4 being 68 birds per farm.

Apart from poultry these farms show only minor differences in the numbers and classes of livestock carried from year to year and as previously stated the same is equally true of the system of cropping. Thus, so far as the livestock and crops are concerned, these farms were and have remained representative of general conditions in the agriculture of Wales.

Farm Capital.

Estimates of the value of the farm capital represent the mean of the opening and closing yearly valuations. In order to avoid any fictitious profits or losses that would possibly arise if market values were taken, standard values were adopted in the case of productive classes of stock and as crops were not an important item of farm sales all crops on hand were valued at standard rates. This will tend to minimise the actual decline in the farm capital as any price fluctuations will only be reflected in the capital invested in non-productive stock. An analysis of the capital is given in Table IV.

Between the years 1930-1 and 1933-4 there was a fall in the farming capital of approximately 7 per cent., allowing for some increases in other items the decline was caused by the depreciation in live stock which shows a decrease of over 9 per cent. This drop mainly affected cattle and sheep and was particularly severe in the case of the latter. While the decline in the capital invested in cattle was only 4 per cent. that for sheep was 29 per cent. Capital invested in horses remained fairly constant in each year while capital invested in pigs fluctuated from year to year and shows no definite tendencies. Poultry stocks have increased each year and this is reflected in the capital which shows an increase of nearly 52 per cent. between 1930-1 and 1933-4. " Dead stock " also shows a slight increase and this is largly due to the fact that some farmers have been adding new labour-saving machinery to their equipment. Crop valuations exhibit a slight rise, due primarily to better yields of cereals and roots and to higher cultivation values.

On an average about 75 per cent. of the total farm capital is invested in livestock, 8 per cent. in crops and 17 per cent. in implements and these proportions remain fairly constant from year to year.

TABLE IV.

Capital invested per 100 Acres.

	1930-1.		*1931-2.*		*1932-3.*		*1933-4.*	
	£ s. d.	% to Total.	£ s. d.	% to Total.	£ s. d.	% to Total.	£ s. d.	% to Total.
Horses	52 7 11	8.7	55 2 2	9.8	55 17 11	9.8	54 5 4	9.7
Cattle	225 7 6	37.6	226 16 0	38.3	218 6 6	38.4	214 7 2	38.4
Sheep	152 16 8	25.5	145 18 2	24.6	121 3 6	21.3	106 11 0	19.1
Pigs	20 19 9	3.5	16 11 11	2.8	12 18 7	2.3	20 16 11	3.7
Poultry	8 7 0	1.4	10 3 10	1.7	13 0 10	2.3	17 4 7	3.1
Total livestock	459 18 10	76.7	454 12 1	76. 7	421 7 4	74.1	413 5 0	74.0
Crops and cultivation	40 12 10	6.8	38 11 8	6.5	48 9 0	8.5	47 19 1	8.6
Implements	94 4 9	15.7	95 12 9	16.2	95 19 6	16.9	95 12 11	17.1
Other items ...	4 14 8	0.8	3 13 3	0.6	2 16 1	0.5	1 16 6	0.3
Total capital	599 11 1	100.0	592 9 9	100.0	568 11 11	100.0	558 13 6	100.0
Relative total capital	100		98		95		93	

TABLE V.

Farm output per 100 Acres.

	1930-1.		1931-2.		1932-3.		1933-4.	
	£ s. d.	% to Total.	£ s. d.	% to Total.	£ s. d.	% to Total.	£ s. d.	% to Total.
Cattle	99 4 10	27.5	77 3 6	28.5	61 5 8	24.8	66 11 8	20.3
Dairy produce	83 4 4	23.0	72 9 8	26.8	74 19 5	30.3	73 15 10	22.4
Total	182 9 2	50.5	149 13 2	55.8	136 5 1	55.1	140 7 6	42.7
Sheep	85 14 7	23.7	42 12 4	15.7	29 0 3	11.7	67 7 8	20.5
Pigs	46 8 2	12.9	26 15 2	9.9	27 10 0	11.1	54 15 3	16.6
Poultry	27 15 4	7.6	27 13 8	10.2	34 12 6	14.0	43 6 1	13.2
Horses ...	6 19 6	1.9	8 19 2	3.3	2 17 6	1.2	11 11 10	3.5
Total Livestock and Livestock products	348 16 9	96.6	255 13 6	94.4	230 5 4	93.1	317 8 4	96.5
Crops	4 13 0	1.3	8 15 11	3.3	11 2 0	4.4	4 4 3	3.2
Sundries	7 14 8	2.1	6 5 2	2.3	6 1 10	2.5	7 8 6	2.3
Total output	361 4 0	100.0	270 14 7	100.0	247 9 2	100.0	329 1 1	100.0
Relative total output	100		75		69		91	

Farm Output.

The farm output is calculated in the case of livestock by taking the total value of the stock on hand at the beginning of the year plus purchases and deducting from it the value of the stock in hand at the end of the year and adding the value of the sales. The same method has been used in the case of crops. No deduction has been made for the cost of foods fed to livestock and in the case of crops the cost of seeds and artificial manures have been omitted. The value and proportional importance of the components of the farm output in each year is given in Table V. The average value of total production per farm fell between the years 1930-1 and 1932-3 by 31 per cent. From 1932-3 to 1933-4 there was a definite increase in the farm output and production stood at 8 per cent. less than what it was in 1930-1. Between the period 1930-1 to 1932-3 the decline in production was more acute in sheep than in cattle, the decrease being about 60 per cent and 38 per cent. respectively. The output in sheep more than doubled from 1932-3 to 1933-4 and while the figures reveal a higher production for cattle the increase amounted to less than 9 per cent. The output of dairy produce declined between 1930-1 and 1933-4 by slightly over 12 per cent. Compared with 1930-1 the production in pigs had fallen by nearly 66 per cent. in 1932-3 but in 1933-4 it was nearly twice as much and stood at about 19 per cent. above that in 1930-1. Poultry production shows a decided increase of slightly over 60 per cent. The output in horses fluctuate from year to year—the lowest was in 1932-3 and the highest in 1933-4. The difference in production between these two years was nearly 78 per cent.

Receipts.

Receipts include all items of farm sales plus the value of the commodities produced on the holding and consumed by members of the household. Rent of farm house has not been included in receipts.

Table VI shows the amount and composition of the gross receipts for each year.

The total receipts show a continuous fall between the years 1930-1 and 1932-3 and the reduction in total sales during that period amounted to over £186 per farm or 25 per cent. From 1932-3 to 1933-4 receipts rose by nearly £71 per farm and although this recovery was made sales were still lower by about £115 per farm or nearly 16 per cent. less than they were in 1930-1.

A study of the items comprising the receipts indicate that

TABLE VI.

Receipts per 100 Acres.

	1930-1.		1931-2.		1932-3.		1933-4.	
	£ s. d.	% to Total.	£ s. d.	% to Total.	£ s. d.	% to Total.	£ s. d.	% to Total.
Cattle	138 9 4	29.6	136 1 7	33.8	100 17 11	29.0	96 5 3	24.6
Dairy produce	83 13 2	17.8	72 16 2	18.1	75 4 6	21.6	73 16 9	18.8
Sheep and wool ...	109 19 11	23.4	89 13 5	22.3	66 2 4	19.0	78 18 5	20.1
Pigs ...	79 17 6	17.0	47 8 2	11.8	44 18 9	12.9	68 10 5	17.5
Poultry and eggs	26 0 0	5.5	27 4 1	6.8	31 10 10	9.0	40 16 8	10.4
Horses	15 11 10	3.3	14 2 9	3.5	12 15 11	3.7	18 10 3	4.7
Total Livestock and Livestock products	453 11 9	96.6	387 6 2	96.3	331 10 3	95.2	376 17 9	96.1
Crops and sundries	15 18 1	3.4	14 15 7	3.7	16 12 3	4.8	15 1 1	3.9
Total Receipts	469 4 10	100.0	402 1 9	100.0	348 2 6	100.0	391 18 10	100.0

the sales of cattle have declined in each year. Between 1930-1 and 1931-2 the decrease was slight and averaged less than £4 per farm. During 1932-3 the reduction in sales was very severe and represented a drop of nearly £58 per farm or 26 per cent. as compared with the figures in 1930-1. Again in 1933-4 there was a further drop of about £7 per farm and in that year cattle sales were nearly £65 per farm or 30 per cent. lower than in 1930-1. The livestock figures indicate that the total cattle population has remained fairly constant from year to year and that no great change has taken place in the number of the different classes of cattle kept. For that reason, the fall in the cattle receipts can be mainly attributed to falling prices and not to a reduction in the number carried or in the system of management.

Sheep and wool sales also showed considerable decline between 1930-1 and 1932-3: the fall being slightly over £68 per farm or 39 per cent. From 1932-3 to 1933-4 there was an increase of £21 per farm and sales were nearly £48 per farm or 28 per cent. less than they were in 1930-1. While there have not been any great variations in the total number of sheep carried from year to year it is noticeable from the livestock records that there has been a definite tendency to increase the number of breeding ewes, and reduce the number of 'other sheep.' The buying-in of store lambs for fattening purposes has been something of a gamble during the period under review and farmers have been changing over to a breeding policy in order to reduce the risks of a falling market.

Pigs show the same general trend as sheep in that there was a fall in the pig receipts between the years 1930-1 and 1932-3—the drop being over £54 per farm or 48 per cent. In 1933-4 pig sales had risen to about £38 more per farm than in the previous year and sales were slightly over 33 per cent. lower than in 1930-1. The pig population followed fairly closely the trend in prices.

Receipts from poultry and eggs have increased each year. For the first three years there was a gradual rise and in 1932-3 poultry and egg sales were slightly over £9 per farm higher than they were in 1930-1. From 1932-3 to 1933-4 receipts rose considerably and averaged nearly £15 more per farm than in the previous year. Between 1930-1 and 1933-4 the increase in sales was nearly 59 per cent. Poultry flocks have increased in numbers during the same period in spite of the fact that prices of poultry and eggs have declined.

Sales of horses show a decline up to 1932-3 but in 1933-4 they were 20 per cent. above those in 1930-1. During the last two years of this study there was a keener demand for horses and prices were higher. Sales of horses do not, however, form an important part of the revenue of these farms and even in 1933-4 only averaged slightly over £29 per farm.

In general, dairy produce has shown a general decline over the whole period and sales per farm in 1933-4 show a decrease of nearly 11 per cent. as compared with 1930-1. Receipts from dairy produce consist mainly of butter sales. There is some liquid milk sold and also small quantities of cheese. Receipts would, however, be influenced more by the prices ruling for butter than for milk and cheese. Butter prices have been very unsatisfactory and have in the last two years been below pre-war level.

Crop sales form but a very small item of total sales and even together with sundry sales did not exceed in any year 5 per cent. of the total.

TABLE VII.

Percentage Increase or Decrease in Receipts as compared with 1930-31. (Base 1930-1 = 100).

	1930-1.	*1931-2.*	*1932-3.*	*1933-4.*
	%	%	%	%
Cattle	100	98.4	78.4	70.2
Dairy produce ...	100	87.1	90.6	89.1
Sheep and wool	100	81.6	60.6	72.5
Pigs	100	59.4	56.7	86.6
Poultry and eggs	100	104.6	122.2	158.6
Horses	100	90.8	82.7	120.1
Total Livestock and Livestock products	100	78.6	78.6	88.9
Crops and sundries	100	94.4	106.8	97.0
Total	100	85.8	74.7	84.4

Livestock and livestock products contributed practically 96 per cent. of the total farm sales, and it is clear that cattle provide the largest individual item in the receipts : together with dairy produce representing about 48 per cent. of the receipts. Sheep and wool again are fairly important and averaged anything from about one-fourth to one-fifth of total sales. The contribution of pigs to total sales varies from year to year—the highest recorded was nearly 18 per cent. and the lowest about 12 per cent. Poultry and eggs increased in importance and while only representing slightly over 5 per cent. of total sales in the first year they reached over 10 per cent. in 1933-4. The

TABLE VIII.

Expenses per 100 Acres.

	1930-1.		1931-2.		1932-3.		1933-4.	
	£ s. d.	% to Total.	£ s. d.	% to Total.	£ s. d.	% to Total.	£ s. d.	% to Total.
Rent	62 8 1	15.7	62 5 11	16.3	63 10 0	20.0	62 2 8	16.9
Rates	5 11 3	1.4	3 7 4	0.9	3 0 11	1.0	2 11 11	0.7
Wages (hired) ...	63 9 5	15.8	63 1 9	16.6	56 14 4	17.9	59 12 0	16.2
Wages (family) ...	27 15 7	7.0	30 1 2	7.9	26 3 1	8.2	29 11 5	8.1
Total wages	91 5 0	22.8	93 2 11	24.5	82 17 5	26.1	89 3 5	24.3
Feeding stuffs	75 0 7	18.8	69 15 10	18.3	66 19 1	21.1	80 18 5	22.1
Manures ...	8 15 4	2.2	7 16 10	2.1	4 11 1	1.4	6 10 4	1.8
Seeds	6 6 1	1.6	5 13 6	1.5	4 3 0	1.3	3 12 2	1.0
Implements and repairs	7 16 9	1.9	9 13 5	2.5	10 6 1	3.2	8 16 5	2.4
Sundries ...	21 13 11	5.4	25 1 11	6.6	19 0 6	6.0	27 9 11	7.5
Livestock bought	120 11 5	30.2	104 3 0	27.3	62 17 10	19.9	85 10 10	23.3
Total expenses	399 8 6	100.0	381 0 8	100.0	317 5 11	100.0	366 16 1	100.0

contributions made by horses and crops are of least importance.

Table VIII sets out the items making up the total expenses.

Expenses.

Rent[2] showed hardly any change and any variation that has occurred is not due to any reduction or increase in the actual farm rentals but to the adding or releasing of small areas of land.

The expenditure on total labour includes an allowance at current rates for unpaid family labour other than that of the occupier and his wife. The total labour costs remain fairly constant and the variation between the highest and lowest labour cost did not exceed £16 per farm. There was a tendency to reduce the amount of hired labour and increase the amount of family labour. Purchases of feeding stuffs have been strongly maintained and while the figures show a tendency towards reduced expenditures in the first three years this can be partly attributed to the fall in the prices of cakes and meals. While the drop in prices of fertilisers is to some extent responsible for the decrease in the expenditure on manures, it cannot account for the heavy cuts made in this respect. The fact that expenditures in the third year (1932-3) were nearly 50 per cent. below those of 1930-1 clearly shows that some attempt has been made to curtail purchases of manures. In the fourth year (1933-4) expenditures were about 25 per cent. below those in 1930-1 and even allowing for the drop in prices consumption was still below that ruling in the first year. Cost of seed has declined in each year and shows a reduction of over 42 per cent. over the whole period. The small reduction in arable land together with the drop in prices of seeds would not account for this wide variation but in order to reduce costs farmers have, as far as it has been possible to do so, been using their own seed and relying on cheaper seed mixtures. Purchases of implements and expenses of employment of tradesmen, etc., have been remarkably maintained and even increased. Purchases of live-stock fell in about the same proportion as sales in the year 1931-2 but were more heavily cut in the next year. In 1933-4 there was a decided increase in expenditure and this amounted to slightly over £36 per farm.

Total expenses (including family labour) fell between the years 1930-1 and 1932-3 by slightly over £125 per farm or approximately 20 per cent. They rose again in the fourth year by nearly £80 per farm and stood at about 7 per cent. less than in 1930-1.

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[2] For owner occupied farms rent has been charged on the basis of "Schedule A" valuation.

Labour and expenditure on purchase of livestock appear to be of equal importance in the farm expenses and together account for about 50 per cent. of the farm costs in each year. Feeding stuffs is another heavy item in the cost budget and

TABLE IX.

Percentage increase or decrease in Expenses as compared with 1930-1. (Base 1930-1 = 100).

	1930-1.	*1931-2.*	*1932-3.*	*1933-4.*
	%	%	%	%
Rent	100	99.9	102.5	100.6
Rates	100	60.4	54.9	47.0
Wages (hired)	100	99.5	90.0	94.8
Wages (family)	100	108.3	94.9	107.5
Total labour	100	102.2	91.5	98.7
Feeding stuffs	100	93.1	89.9	108.9
Manures	100	89.4	52.3	75.1
Seeds	100	90.2	66.2	57.8
Implements and repairs	100	123.4	132.4	113.7
Sundries	100	115.8	88.3	128.0
Livestock bought	100	86.4	52.5	71.6
Total expenses	100	95.5	80.1	92.8

ranges from 18 to 22 per cent. of the total charges. The proportion of rent to total expenses varies from 16 to 20 per cent.

In each year there has been an excess of receipts over expenses. The position is as follows :

	1930-1			*1931-2*			*1932-3*			*1933-4*		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Receipts (per farm)	736	17	5	631	19	5	550	15	2	621	10	9
Expenses (per farm) (including wages due to sons and daughters)	627	4	6	598	17	7	501	19	9	581	13	11
Surplus	109	12	11	33	1	10	48	15	5	39	16	10

Actual cash receipts were slightly higher than cash expenditure in each year but for the last three years the surpluses were less than one-half that of 1930-1. Judging the results on this basis the returns to the farmer were equal to £2 2s. per week in 1930-1 and for the other years the returns varied from 12s. 8d. to 18s. 9d. per week.

Financial Results.

The financial results for these farms in terms of gross income, farm income and labour income are stated in Table X.

Gross Income represents the balance between receipts and expenses after allowing for any difference between the opening and closing valuation. It represents the fund from which are drawn wages of family labour, earnings of management by the farmer and also interest on the capital invested in the farm business. *Farm income* is the balance remaining after

TABLE X.

Gross Income, Farm Income and Labour Income.

	Per Farm.			
	1930-1.	*1931-2.*	*1932-3.*	*1933-4.*
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Gross income	169 18 2	41 13 5	30 0 0	124 2 5
Farm income	126 5 9	5 11 5 (a)	11 7 7 (a)	77 4 6
Labour income	69 16 1	61 8 10 (a)	65 6 10 (a)	24 1 3

	Per 100 Acres.			
	1930-1.	*1931-2.*	*1932-3.*	*1933-4.*
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Gross Income ...	108 4 0	26 10 3	18 19 3	78 5 4
Farm Income ...	80 8 5	3 10 11 (a)	7 3 10 (a)	48 13 11
Labour Income ...	44 9 0	39 1 7 (a)	41 6 0 (a)	15 3 6

(*a*) Minus quantities.

deducting from gross income wages of family labour other than that of the farmer and his wife. It covers earnings of management, interest on capital and work done by the occupier and his wife. *Labour Income* is calculated by deducting from farm income an interest charge on the capital invested. In assessing this charge consideration must be given to the risks involved in farming and interest has been allowed at the rate of 6 per cent. on the capital invested.

In 1930-1 these farms showed a gross income of nearly £170 per farm of which about £43 was for family wages, about £56 was for interest on capital and nearly £70 was for management. In 1931-2 the gross income was about £6 short of the amount due to the family for manual work done, viz. £47 4s. 10d. There was no interest on capital and nothing for management, and capital was reduced by slightly over £10 per farm. Conditions did not improve in 1932-3. The amount due for family labour

was £41 7s. 7d. while the gross income was only £80. Again there was nothing for interest or management and capital was further depleted by nearly £32 per farm. During 1933-4 conditions improved and the gross income rose to slightly over £124 per farm while the value of family labour was £46 17s. 11d. After interest had been allowed on capital at the rate of 6 per cent. there was £24 1s. 3d. left for management. Capital again diminished by a little over £14 per farm. The average farmer's earnings were still nearly £46 short of what they were in 1930-1. In these calculations there is nothing to add for the values of the farm produce consumed in the house. These have already been included in the receipts and the amount in respect of each year is as follows:

Value of Produced Consumed.

Year.	£	s.	d.
1930-1	43	18	5
1931-2	45	6	0
1932-3	44	11	3
1933-4	40	9	11

In 1931-2 and 1932-3 the value of the produce consumed was greater than the gross income and in these years the average gross income did not provide any cash that could be used for private expenditure. During these years the average family was giving its labour and capital to the farm and getting in return a little farm produce for consumption and at the same time suffering some loss on capital. In 1933-4 the average farmer was still giving part of his management labour without pay and capital was still being depleted. The managerial earnings even in 1930-1 were below those of an adult hired worker at current rate of wages.

The varying degrees of profits and losses for these farms cannot be reasonably attributed to the farming circumstances of a particular year but rather to the difficulty which farmers have experienced in keeping their organisation adjusted to rapidly changing levels of prices and costs. The index numbers for "crop-years"[3] published by the Ministry of Agriculture for the period reviewed show that agricultural prices on the whole fell by nineteen points between the years 1930-1 and 1932-3, but some recovery was made in 1933-4 when the index number rose by seven points. The price changes that have occurred have varied widely for different commodities. In general, prices of

[3] The figures for the crop year have been taken in preference to the calendar year as the data more closely represents the trend of prices for the accounting period covered.

cereals showed no signs of recovery. Excluding the wheat deficiency payment wheat prices declined in the third and fourth year and over the whole period stood below pre-war level. Some improvement was noticeable in barley in 1933-4 when the index figures stood at 112 as against ninety-two in the previous year. Apart from the second year when the index number stood at 101 prices of oats were below pre-war level. A decline in the price of hay is noticeable in the first three years, and while some recovery was made in the fourth year prices were still below those in 1930-1. Owing to the small crop in 1931 the index figure for potatoes was 230 in 1931-2 but in the following year it fell to 108 and to 107 in 1933-4. The growing of crops especially for sale is of minor importance on these farms and crop prices would therefore not influence the financial returns on these holdings, but variations in prices of livestock and especially store stock and livestock products have a very important bearing on the farming results. For the period under review there was a depression in prices of all classes of cattle and in particular in the store cattle trade, where the index figure fell from 127 in 1930-1 to eighty-six in 1933-4. The drop of twenty-six points in fat cattle or twenty-four points in dairy cows for the same period was not as severe as in the case of store cattle. Prices of fat sheep fell in each year, the difference in the index figure between 1930-1 and 1933-4 being twenty-six points. The index number for store sheep fell from 146 in 1930-1 to eighty in 1932-3 and rose again in 1933-4 to ninety-five or 5 per cent. below pre-war level. Prices of bacon pigs fluctuated from year to year. They were lowest in 1931-2 when the index figure stood at 8 per cent. below pre-war level. Conditions improved slightly in 1932-3 and the index figure at 112 in 1933-4 showed a drop of nine points as compared with that in 1930-1. Prices of porkers showed similar trends. Store pigs declined in price between 1930-1 and 1932-3, the earlier index figure being 136 as against 109. In the fourth year the index figure stood at 142, or six points above that in 1930-1. Poultry and egg prices have declined over the whole period, the drop in poultry being slightly over 18 per cent. and in eggs nearly 10 per cent. Milk prices declined in the first three years but in 1933-4 prices improved and were slightly better than those ruling in 1930-1. Butter realised less money in each year and stood below pre-war level in 1932-3 and 1933-4. The index figure was 114 in 1930-1 as against ninety-one in 1933-4. Cheese prices improved between 1930-1 and 1931-2 but fell again in the last two years. Wool prices were 48 per cent. below pre-war level in 1930-1 and 55 per cent.

in 1931-2. In 1932-3 there was an upward movement and this was continued in 1933-4 when prices stood at 20 per cent. below pre-war level.

Against these lower values of production must be considered any reductions in farm costs.The index figure for feeding stuffs shows a fall from ninety-six in 1930 to eighty-five in 1933, or slightly over 11 per cent. Fertilisers for the same period indicate a drop of nearly 10 per cent. Rent remains at about the same figure. Official representative figures are not available for cost items of wages, seeds and implements. The National Farmers' Union estimate that since 1913 the actual cost of labour allowing for shortened hours has rather more than doubled. This estimate, however, is on the high side and 70 per cent. above pre-war level would be more indicative of actual costs. The increase in price of farm seeds would be about 20 per cent. and machinery and implements about 60 per cent. above pre-war level. It would appear therefore that farm costs on the whole have not declined at the same rate as prices of farm produce and that the farmer has to pay the same for many of his requirements although he has to sell most of his products at reduced prices.

CONSUMPTION OF MILK IN A DISTRESSED AREA OF SOUTH WALES.

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An investigation made last year into milk consumption in a part of the City of Cardiff[1] demonstrated the need of making similar studies in areas having well defined economic and social features. Information provided by such studies supply people interested in the production and distribution of milk with important facts. On the basis provided by such facts planning to meet specific needs can be done by public health authorities, milk selling agencies, milk publicists and individuals interested in the milk market and the consumption of milk. Schemes designed to increase milk consumption may well prove ineffective in areas having very different social and economic features. Their effectiveness may be limited by conditions peculiar to a

[1] *Welsh Journal of Agriculture*, Vol. X. Jones and Cowie.

district or area which investigation alone can bring to light. The aim of this study is to examine the influences having a bearing on milk consumption in the area to which the study relates.

The Department[2] designed an investigation into the consumption of fresh milk and milkstuff in a part of the Rhondda Valley. This valley is one of the best known coal mining areas in Britain. At its best it was a hive of economic and industrial activity. During this period the people of the Rhondda enjoyed unprecedented economic prosperity. By now, however, there has been an alarming fall in industrial activitiy with consequent depression. The movement towards decline in coal mining began about 1921 and since then there has been an almost continuous fall in employment. There have been short-lived spurts of activity in the coal mines but none were sustained. Despite all efforts to improve trade in coal there has been a continued and relentless fall in industrial and economic activity. Employers fought for lower wages and introduced labour saving devices in an attempt to maintain profits; employees struggled dourly to avoid lower wages. The resulting industrial conflict made trade still worse and aggravated an industrial situation already very serious. By the combination of the circumstances outlined the Rhondda Valley and its people, once raised to economic prosperity by the hard and hazardous work of coal mining, have been reduced to the depths of industrial inactivity. Men and women who once enjoyed prosperity now suffer privation. Indeed had it not been for the relief obtained from the national social services and charity the burden of living in this area would have become intolerable and impossible.

Despite all these viccissitudes it must not be inferred that the area is derelict or its people without hope of better times. All realise that things are bad and most people believe that better times will come. Even young people who now seek work elsewhere look forward to returning to the mines.

This is briefly the background against which this study of milk consumption was made. Great care had to be taken in the selection of an area representative of conditions in the Rhondda Valley as a whole. Public bodies and persons with experience of public affairs in the Rhondda Valley were consulted in the choice of sample. The districts Tonypandy, Penygraig and Trealaw were selected and surveyed by a team directly from this Department. Particulars of the constitution of households, income received, fresh milk and milkstuff bought or received were obtained for the week July 8th-14th.

[2] Department of Agricultural Economics, U.C.W., Aberystwyth.

As seasonal influences affect milk consumption, it should be said that weather conditions were fairly normal for the time of year, if anything, perhaps a little warmer and drier than usual. Volume of employment during the week of the survey was about normal, but several people stated that more work was available in the week preceding the survey and the money earned would be available for spending during the week the survey was made. In an area which of necessity must live from " hand to mouth " it is unlikely that this fact exerted much influence. In many households money is spent before pay day. In such cases money is earned and spent in the same week. Few people were away on holiday and there was no special seasonal illness. It is therefore reasonable to regard the period as normal for the time of year.

Information was collected separately for the three districts surveyed and part of the analysis has been done on a similar basis. The three districts are contiguous and except to persons with a good knowledge of the districts separation of them would be impossible.

Penygraig is reputed to be the best district and is somewhat of a " residential " character; Tonypandy is a business and shopping centre; Trealaw mainly a working class district.

The data as collected and classified for the three districts taken together is shown in Table I. The number of households in the three districts is roughly in proportion to the population. Household constitution varies considerably in the three districts. Income is stated in four groups, all items of " private " (as from rents or investments) income being excluded. The relation of monies received from wages or salaries, unemployment benefit, public assistance and pensions is interesting. In Tonypandy 66 per cent. of the income is derived from wages or salaries, 24 per cent. from unemployment benefit, 4 per cent. from public assistance and 6 per cent. from pensions; the percentages are almost the same for Penygraig, being 66 per cent., 28 per cent., 3 per cent. and 3 per cent. respectively; the percentages are vastly different for Trealaw, being 50.4 per cent., 38.4 per cent., 5.2 per cent. and 6 per cent. respectively. Over the three districts income is made up of wages six-tenths, unemployment benefit three-tenths, and public assistance and pensions one tenth.

Total quantities, values and grades of fresh milk purchased varied between district and district. Fresh milk (loose) expressed as a percentage of total milk purchased was 45.8 per cent. in Tonypandy, 30.4 per cent. in Penygraig, 47.2 per cent. in Trealaw

and 40.2 per cent. in all districts; fresh milk (bottled) expressed on the same basis was 58.1 per cent. in Tonypandy, 62.9 per cent. in Penygraig, 51.5 per cent. in Trealaw, and 56.5 per cent.

TABLE I.

Analysis of Total Households, Incomes and Milk, etc., by Areas.

	Tonypandy.		Penygraig.		Trealaw.		Total all Districts.	
Households	192		217		193		602	
(1) Constitution of Households.								
(a) No. of children under 7	88		131		153		372	
(b) Children 7—14	119		139		166		424	
(c) Adults (over 14)	651		757		704		2,112	
Total persons	858		1,027		1,023		2,908	
(2) Weekly Incomes:	£ s. d.		£ s. d.		£ s. d.		£ s. d.	
(a) Wages or Salaries	349 14 3		404 3 11		257 9 3		1,011 7 5	
(b) Unemployment Benefit	128 13 7		172 19 6		196 8 1		498 1 2	
(c) Public Assistance	23 2 6		17 3 6		26 1 3		66 17 3	
(d) Pensions	29 18 6		21 4 6		30 10 11		82 13 11	
Total per week	531 8 10		616 1 5		511 9 6		1,658 19 9	
	Quantity.	*Value.*	*Quantity.*	*Value.*	*Quantity.*	*Value.*	*Quantity.*	*Value.*
(3) Purchases of Liquid Milk:	Pints.	£ s. d.	Pints.	£ s. d.	Pints.	£ s. d.	Pints.	£ s. d.
(a) Loose	585⅛	7 6 3½	445⅜	5 7 11½	487½	6 1 9½	1518⅛	18 16 0½
(b) Bottled	679	8 9 9	921⅝	11 10 4½	530½	6 12 9½	2131	26 12 11
(c) Graded	14½	0 14 10	98½	1 12 2½	11	0 3 8	124	2 0 8½
Total	1278⅝	16 0 10½	1465½	18 10 6½	1029	12 18 3	3773⅛	47* 9 8
(4) Purchases of Condensed Milk:								
(a) Skimmed M.E. (Pints)	367⅞	3 6 11½	399⅛	3 12 8½	544	4 16 3½	1311	11 15 11½
(b) Whole M.E. (Pints)	80⅞	1 8 1½	55⅛	1 0 6½	68¾	1 3 5½	205½	3 12 1½
Total	448¾	4 15 1	454¼	4 13 3	612¾	5 19 9	1516½	15 8 1
(5) Supplies of Milk Powder, etc.:								
(a) Milk Powder M.E. (Pints)*	45½	0 6 6½	168	1 2 5½	147	0 1 8	360½	1 10 8
(b) Malted Milk	—	0 6 7½	—	0 7 1	—	0 2 4½	—	0 16 1
Total†	—	0 13 2	—	1 9 6½	—	0 4 0½	—	2 6 9
(6) Purchases of Cream:								
(a) Fresh,	56	0 10 10½	122	1 3 1½	38	0 6 9	216	2 0 9
(b) Tinned,	385½	1 5 10	386½	1 5 8½	326½	1 0 11½	1098½	3 12 6
Total	441½	1 16 8½	508½	2 8 10	364½	1 7 8½	1314½	5 13 3
(7) Public Supplies of Milk: Pints.								
(a) School	100	0 0 10	167½	—	260	0 0 5	527½	0 1 3
(b) Clinic	83	—	200½	—	232½	—	516½	—
Total	18[illegible]	—	368	—	492½	—	1044	—

* Milk Equivalents of Milk Powder only. † Costs of Milk Powder and Malted Milk.

of the total in all districts; little special grade fresh milk was purchased, namely, 1.1 per cent. in Tonypandy and Trealaw, 6.7 per cent. in Penygraig, and 3.3 per cent. over the whole area.

Of the 602 households surveyed, fresh milk was purchased by 499 households consisting of 1,771 adults and 581 children. Allowing for fresh milk supplied from public sources 561 households consisting of 1,972 adults and 754 children received supplies of fresh milk. The forty-one remaining households consisting of 140 adults and sixty-two children received no supply of fresh milk and four of these households consisting of ten adults and five children did not purchase or receive supplies of " milkstuff " of any kind.

Fresh milk was purchased in Tonypandy by 176 households consisting of 596 adults and 178 children; in Penygraig fresh milk was purchased by 178 households consisting of 628 adults and 193 children; in Trealaw fresh milk was purchased by 145 households consisting of 547 adults and 210 children. Allowing for supplies of fresh milk from public sources 184 households consisting of 621 adults and 198 children received fresh milk in Tonypandy; 206 households consisting of 723 adults and twenty-five children in Penygraig, and 171 households consisting of 628 adults and 297 children in Trealaw.

The proportion of households purchasing fresh milk was greatest in Tonypandy (92 per cent.), followed by Penygraig (88 per cent.), and Trealaw (75 per cent.). In all the three districts 82 per cent. of the households purchased supplies of fresh milk.

Purchase of condensed skimmed and whole milk was widespread. The quantities recorded have been converted to common terms for basis of comparison, but the quantities given can be only approximate.* Costs are given in each case and expenditure at any rate provides an exact and uniform basis of comparison.

More milk powder was received free from public sources than was purchased. Malted milk was consumed only in very small quantities.

Cream, particularly in fresh state, was purchased only in small quantities in all districts. The use of tinned cream was more general but still low.

Large quantities of fresh milk were supplied from public sources to children in schools and to other necessitous cases in clinics. Almost the whole of this supply was given without charge and was equal to about one-third of the fresh milk purchased and one-fifth of the total fresh milk used.

The relation of total expenditure on fresh milk and other types of " milkstuff " in the three areas is shown in Table II.

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* M.E. = Milk Equivalent.

The ratio of expenditure on fresh milk and other "milk-stuff" is almost the same as the ratio of quantities purchased and used. There is evidence of lowest relative purchases of fresh milk coinciding with the highest relative cost of condensed milk, so there are obviously real cases of substitution in the purchases of fresh and condensed milk. Whether the change-over from

TABLE II.

	Fresh Milk.	*Condensed Milk.*	*Milk Powder.*	*Cream.*	*Total.*
	%	%	%	%	%
Tonypandy	68.9	20.4	2.8	7.9	100
Penygraig	68.3	17.2	5.4	9.1	100
Trealaw	63.0	29.2	1.0	6.8	100
Total	66.9	21.8	3.3	8.0	100

fresh milk to condensed milk makes a real saving in cost per unit of milk is extremely doubtful, and the comparison in Table III brings out this fact.

TABLE III.

Average cost of Fresh Milk and other Milkstuff per unit.

	d.
Fresh Milk (all grades).	
Per pint	3.020
Condensed Milk.	
Skimmed (per pint M.E.) .	2.159
Whole (per pint M.E.)	4.211
Average . .	2.137
Cream.	
Fresh (per oz.) .	2.263
Tinned (per oz.) ...	0.782

Fresh milk was cheaper, on the average, than whole condensed milk by nearly 1¼d. per pint and the skimmed variety of condensed was about 0.86d. per pint cheaper than the fresh. Taking everything into consideration the condensed milks were much dearer than the fresh. No costs of the "milk equivalents" of milk powder or malted milk have been estimated. The consumption of the latter was small and only part of the supply of the former was purchased.

The relative costs of the two varieties of cream show an appreciable difference, fresh being about three times the price of tinned and it may be easily understood why purchases of tinned amounted to five times that of the fresh variety.

More detailed examination of the data is possible in Table IV, where comparison is made by households and averages for households stated.

For further consideration of the distribution of purchases it is necessary to obtain a detailed view of the constitution of the households. Trealaw had almost twice as many children under seven years as Tonypandy, Penygraig coming mid-way between the two; again Trealaw had the greatest number of children of 7-14 years, but the difference was less than in the under seven years class. Differences in adults per household are still smaller, Trealaw again being highest. The same order was maintained in total persons per household. Children under seven years and 7-14 years, and adults per household were above the average for the three districts in Trealaw and below this average in Tonypandy and Penygraig.

The income per household for all districts was £2 18s. 1¼d. Penygraig had the highest income per household, Tonypandy being 1s. 5d. lower and Trealaw 3s. 9d. below Penygraig. Income per household and fresh milk purchases showed a very close association. The households of Penygraig purchased most and those of Tonypandy followed, while those of Trealaw purchased about 1½ pints per household below the average quantity bought in the three districts. Where the purchase of fresh milk was lowest the purchase of condensed tended to be highest. Trealaw purchased more of this variety of " milkstuff " than Tonypandy and Tonypandy more than Penygraig.

At least two-thirds of the milk powder consumed was provided free by public health authorities and the total quantity purchased was small. But it is a matter of some importance that purchase and use of milk powder was increasing in the better areas. The main reason for this is that people visiting clinics act on the advice obtained and more use is now made of the clinics by people of all social grades. The consumption of malted milk was very low and mainly confined to people having an acquired taste for it and the means to satisfy that taste.

Fresh cream is regarded as the "aristocrat" of "milkstuffs," and people who can afford it purchase when means are available. Penygraig showed much the highest purchases of fresh cream, Tonypandy followed, with Trealaw purchasing only about half the average for the three districts. Greater quantities of tinned cream were purchased and distribution in the three areas followed the same order as in the case of fresh.

When supplies of fresh milk from public sources are added to supplies of fresh milk purchased, there is a levelling-up of the

supply of fresh milk per household in each district. On this basis the supply of fresh milk per household per week is as follows :—

Tonypandy	....	7.525 pints.
Penygraig	....	8.430 pints.
Trealaw	....	7.883 pints.
Mean	....	7.991 pints.

TABLE IV.

Analysis of Households, Incomes and Total Milk by Areas. Averages per Household.

	Tonypandy.		Penygraig.		Trealaw.		Average, All Districts.	
(1) Constitution of Household.								
(a) No. of Children under 7	0.46		0.60		0.70		0.62	
(b) Children 7—14 ...	0.62		0.64		0.86		0.70	
(c) Adults over 14) ...	3.39		3.49		3.65		3.51	
Total Persons	4.47		4.73		5.30		4.83	
	£ s. d.		£ s. d.		£ s. d.		£ s. d.	
(2) Weekly Incomes.								
(a) Wages or Salaries	1 16 5		1 17 3		1 6 8¼		1 13 7¼	
(b) Unemployment Benefit	0 13 5		0 15 11½		1 0 4¼		0 16 6¼	
(c) Public Assistance .	0 2 5		0 1 7		0 2 8½		0 2 2¾	
(d) Pensions	0 3 1		0 1 11½		0 3 3		0 2 9	
Total per week	2 15 4		2 16 9		2 13 0		2 15 1¼	
	Quantity Pints.	*Value Pence.*	*Quantity Pints.*	*Value Pence.*	*Quantity Pints.*	*Value Pence.*	*Quantity Pints.*	*Value Pence.*
(3) Purchases of Liquid Milk.								
(a) Loose	3.000	9.00	2.050	5.97	2.530	7.57	2.520	7.49
(b) Bottled	3.500	10.60	4.240	12.74	2.750	8.24	3.530	10.62
(c) Graded	0.075	0.30	0.450	1.22	0.053	0.21	0.205	0.81
Total	6.575	19.90	6.740	19.93	5.333	16.02	6.255	18.92
(4) Purchases of Condensed Milk.								
(a) Skimmed M.E. (Pints)	1.90	4.18	1.84	4.02	2.82	5.99	2.18	4.70
(b) Whole M.E. (Pints)	0.42	1.75	0.25	1.13	0.35	1.46	0.34	1.44
Total	2.32	5.93	2.09	5.15	3.17	7.45	2.52	6.14
(5) Supplies of milk Powders, etc.								
(a) Milk Powder M.E. (Pints)*	0.23	0.41	0.77	1.24	0.76	0.10	0.60	0.61
(b) Malted Milk	—	0.41	—	0.39	—	0.15	—	0.32
Total†	—	0.82	—	1.63	—	0.25	—	0.93
	Ozs.	*Pence.*	*Ozs.*	*Pence.*	*Ozs.*	*Pence.*	*Ozs.*	*Pence.*
(6) Purchases of Cream.								
(a) Fresh	0.290	0.68	0.560	1.27	0.196	0.42	0.360	0.81
(b) Tinned	2.000	1.61	1.780	1.42	1.690	1.30	1.820	1.45
Total	2.290	2.29	2.340	2.69	1.886	1.72	2.180	2.26
	Pints.	*Pence.*	*Pints.*	*Pence.*	*Pints.*	*Pence.*	*Pints.*	*Pence.*
(7) Public Supplies of Milk.								
(a) School	0.520	0.052	0.770	—	1.350	0.025	0.876	0.025
(b) Clinic	0.430	—	0.920	—	1.200	—	0.860	—
Total	0.950	—	1.690	—	2.550	—	1.736	—

* Milk Equivalents of Milk Powder only. † Costs of Milk Powder and Malted Milk.

The districts in which purchases of fresh milk were lowest gained the most by the provision of fresh milk from public sources.

TABLE V.

Analysis of Households, Incomes and Total Milk by Areas. Averages per Person.

	TONYPANDY.		PENYGRAIG.		TREALAW.		AVERAGE, ALL DISTRICTS.	
	£ s. d.		£ s. d.		£ s. d.		£ s. d.	
(1) WEEKLY INCOMES.								
(*a*) Wages or Salaries .	0 8 2		0 7 10¾		0 5 0½		0 6 11½	
(*b*) Unemployment Benefit	0 3 0		0 3 4¼		0 3 10¼		0 3 5	
(*c*) Public Assistance .	0 0 6½		0 0 4		0 0 6		0 0 5½	
(*d*) Pensions	0 0 8¼		0 0 5		0 0 7¼		0 0 7	
Total per week	0 12 4¾		0 12 0		0 10 0		0 11 5	
	Quantity Pints.	*Value Pence.*	*Quantity Pints.*	*Value Pence.*	*Quantity Pints.*	*Value Pence.*	*Quantity Pints.*	*Value Pence.*
(2) PURCHASES OF LIQUID MILK.								
(*a*) Loose	0.680	2.020	0.430	1.250	0.480	1.430	0.520	1.550
(*b*) Bottled	0.790	2.370	0.900	2.700	0.520	1.560	0.730	2.200
(*c*) Graded	0.016	0.067	0.095	0.250	0.011	0.040	0.042	0.170
Total	1.486	4.457	1.425	4.200	1.011	3.030	1.292	3.920
(3) PURCHASES OF CONDENSED MILK.								
(*a*) Skimmed M.E. (Pints)	0.430	0.940	0.390	0.850	0.530	1.120	0.450	0.970
(*b*) Whole M.E. (Pints)	0.094	0.390	0.053	0.240	0.070	0.275	0.070	0.300
Total............	0.524	1.330	0.433	1.090	0.600	1.395	0.520	1.270
(4) SUPPLIES OF MILK POWDERS, ETC.								
(*a*) Milk Powder M.E. (Pints)*	0.052	0.090	0.160	0.260	0.140	0.019	0.124	0.126
(*b*) Malted Milk	—	0.090	—	0.082	—	0.027	—	0.066
Total†	—	0.180	—	0.342	—	0.046	—	0.192
	Ozs.	*Pence.*	*Ozs.*	*Pence.*	*Ozs.*	*Pence.*	*Ozs.*	*Pence.*
(5) PURCHASES OF CREAM.								
(*a*) Fresh	0.065	0.160	0.120	0.270	0.037	0.079	0.047	0.168
(*b*) Tinned	0.450	0.360	0.380	0.300	0.320	0.240	0.380	0.300
Total	0.515	0.520	0.500	0.570	0.357	0.319	0.427	0.468
	Pints.	*Pence.*	*Pints.*	*Pence.*	*Pints.*	*Pence.*	*Pints.*	*Pence.*
(6) PUBLIC SUPPLIES OF MILK.								
(*a*) School	0.116	0.116	0.160	—	0.250	0.004	0.180	0.005
(*b*) Clinic	0.097	—	0.195	—	0.220	—	0.180	—
Total	0.213	—	0.355	—	0.470	—	0.360	—

* Milk Equivalents of Milk Powder only. † Costs of Milk Powder and Malted Milk.

Comparisons per person are made in Table V. Here again all households surveyed are taken into account. Differences in the income in the three districts are substantial when expressed on this basis. Tonypandy showed the highest income per person and Penygraig was a little lower, whilst Trealaw was appreciably lower. Both the former districts have higher incomes per person

than the average income per person for the three districts. Trealaw was much below the average in this respect.

The purchases of fresh milk per person were extremely low in all districts and they are striking when expressed in this manner. The relative positions of Tonypandy and Penygraig as purchasers of fresh milk were changed, but Trealaw still took the lowest position. This change in position compared with Table IV is due to differences in the numbers of persons per household in the three districts. It appears from this that there is a close relationship between income per person and the amount of fresh milk purchased. This problem is treated in a later section of the study and the results there support the view now expressed.

Again the relationship shown in Table IV between fresh milk purchased and condensed milk is maintained. In those districts where the purchase of fresh milk was lowest the purchase of condensed milk was highest. This again seems to point to a higher consumption of condensed milk in districts showing low incomes per person.

Supplies of milk powder, as previously stated, were partly obtained free from clinics and partly by purchase from clinics and chemists' and druggists' stores. The purchase of malted milk, however, was extremely low and figures follow the same trend as for the purchase of fresh milk.

Purchases of fresh and tinned cream were very low and quantities follow the same trend as for fresh milk, those purchased being highest in districts where the average income per person was highest.

Public supplies of fresh milk were highest in the districts where the income per person was lowest, thus raising the average supply per person per week in the poorer districts.

Pints per person per week.

Tonypandy ...	1.699 pints.
Penygraig ...	1.780 pints.
Trealaw ...	1.481 pints.
Mean ...	1.652 pints.

If households with children are the heaviest purchasers of fresh milk, there is likely to be a diminution in purchases when an alternative and cheaper source of fresh milk for school children exists at the schools. This will tend to lower the demand for milk from commercial distributors. The influence on the effective demand for milk may be inevitable so long as incomes are low; but the provision of milk in school at half price will

be a real saving to public health authorities and a real economy as it safeguards the health of the child.

A summary of the general results of the investigation covering all districts surveyed is presented here before more detailed problems are treated.

		Average per household.
Number of Households	602	
Children	796	1.32
Adults	2,112	3.51
Total persons	2,908	4.83
Incomes		£2/15/1¼
Purchases of Fresh Milk—Quantity		6.26 pints.
Value		19.07 pence.
Purchases of Condensed Milk—Quantity		2.52 M.F. pints.
Value		6.14 pence.
Supplies of Milk Powder and Malted Milk—		
Purchased		0.52 pence.
From Public sources		0.11 pence.
		0.93 pence.
Purchases of Cream		2.26 pence.
Public Supplies of Milk—Quantity		1.73 pints.
Value (approximately)		5.19 pence.

On the average these 602 households, consisting of 4.83 persons, received per household about eight pints of fresh milk, of which nearly 6.3 pints were purchased and 1.73 pints were received free from various public sources. The average daily consumption of fresh milk was therefore 0.236 pints per person. It is difficult to obtain an exact estimate of the liquid milk equivalent of all forms of "milkstuff," but excluding cream, the weekly quantity is about 3.1 pints per household and 0.64 pints per person. Thus the total of "milk," including liquid milk, condensed milk, milk powder and malted milk, excluding cream, is about 0.327 pints per person daily consumption. The average weekly value of milk and "milkstuff," including cream, purchased and received from public sources was 33.6d. per household or less than 7d. per person—less than one penny per day per person.

Estimated Consumption of Fresh Milk in the Rhondda Valley.

The estimated consumption of fresh milk in pints per day per person in the Rhondda Urban District for the years 1924-33 was 0.178, 0.182, 0.172, 0.158, 0.170, 0.175, 0.170, 0.191, 0.227, and 0.245; the estimated population of the area was 140,850 in 1932 and 139,500 in 1933.[3]

[3] Reports of the Medical Officer, Rhondda Urban District Council. The figure for 1933 is calculated from statistics provided by the above authority but not published at time of survey.

The districts surveyed in this study have an estimated population of 28,000-30,000, and the survey covered 2,908 people —roughly a tenth of the total population in the three districts and one-forty-eighth of the 1938 population of the Urban district. In the survey the average consumption of fresh milk purchased in pints per head per day was found to be 0.185 but this figure is increased to 0.236 when fresh milk supplied in schools and clinics is taken into account.

In making comparison of these figures collected by two bodies working independently it must be realised the figure given by the Medical Officer covers the whole of the year. The figure obtained by survey, however, only tells how much fresh milk was consumed in one week of July. Still there is a remarkable agreement in the two figures. The comparison indicates that the survey results are reliable and that the area surveyed is a representative sample of the Rhondda Urban District.

Milk Consumption in Households taking Liquid Milk.

The consumption and cost of fresh milk for only those households purchasing fresh milk is stated in Table VI on a household basis, and a comparison is made with the figures obtained when all households are taken into consideration

TABLE VI.

Weekly Variations in Fresh Milk Purchases between Households buying Liquid Milk and all Households.

District.	*All Households.*		*Households purchasing liquid milk.*		*Difference.*	
	Pints.	*Cost.*	*Pints.*	*Cost.*	*Pints.*	*Cost.*
		d.		*d.*		*d.*
Tonypandy	6.575	19.900	7.265	21.878	0.690	1.978
Penygraig	6.740	19.930	8.338	24.980	1.498	5.050
Trealaw	5.333	16.020	7.096	21.372	1.763	5.352
Mean	6.225	18.920	7.561	22.829	1.426	3.909

The relative order of quantity and cost of fresh milk purchased per household in the three districts is the same when only households buying fresh milk are taken into account as when all households are considered. The average quantity and cost of fresh milk purchased is higher in each district. The difference in quantities and cost are greatest for Trealaw; Penygraig follows and Tonypandy shows least though substantial difference, while the varation from the mean is significant.

A similar comparison on a *per capita* basis confirms the tendency shown in Table VI.

TABLE VII.

District.	*All Households.*		*Households purchasing liquid milk.*		*Difference.*	
	Pints.	*Cost.*	*Pints.*	*Cost.*	*Pints.*	*Cost.*
		d.		*d.*		*d.*
Tonypandy	1.486	4.457	1.652	4.975	0.166	0.518
Penygraig	1.425	4.200	1.785	5.409	0.360	1.209
Trealaw	1.011	3.030	1.359	4.104	0.348	1.074
Mean ...	1.292	3.920	1.605	4.847	0.313	0.927

In this case again Tonypandy shows the highest quantities and cost of fresh milk for all households, but Penygraig is highest when only households purchasing fresh milk are considered. Trealaw is lowest in both cases. The difference between the amount and cost of fresh milk in the two groups is least in Tonypandy, followed by Trealaw, and greatest in Penygraig, but the figures for Penygraig and Trealaw are almost identical. The reason why the differences in figures in Table VII are not in the same ratio as the differences in figures in Table VI is the varying number of persons per household in the three districts. The numbers of persons per household buying liquid milk in the three districts are as follows : Tonypandy, 4.397 ; Penygraig, 4.612, and Trealaw, 5.221.

From these figures it is clear that there is room for increase in the consumption of fresh milk in all the areas by merely getting all households to purchase fresh milk. Scope for increase in consumption on this basis is greatest in Penygraig and Trealaw, and least in Tonypandy, but appreciable for all three districts taken together.

Week-end variation in purchases of Fresh Milk.

Only households purchasing liquid milk are taken into consideration in ascertaining this variation in daily purchases, and supplies of fresh milk from public sources are ignored. Moreover, the comparison is made by districts.

There was considerable variation in week-end purchases of fresh milk in all districts. Purchases on Sunday exceeded the average for other days of the week. The variation was highest for Trealaw, followed by Tonypandy and least in Penygraig; purchases on Monday were lower than the daily average in all

districts excepting Trealaw, where they slightly exceeded the average. The increase in purchase of milk on Sunday averages two-fifths pints in Penygraig, eleven-twentieths pints in Tonypandy and thirteen-twentieths in Trealaw. It appears that income affects the range of variation between purchases of fresh milk on Sunday and other days of the week for the variation is greatest where income per person is lowest. Dietary habits have

TABLE VIII.

Week-end variation in pints per day per Household.

District.	*Sunday.*	*Monday.*	*Average of other days.*	*% of Households buying liquid milk.*
Tonypandy ...	1.519	0.879	0.955	92
Penygraig	1.475	1.076	1.080	82
Trealaw	1.602	0.975	0.954	75
Mean	1.528	0.976	0.997	83

an important influence on purchases of fresh milk on Sunday. There are well established week-end dietary habits in the Rhondda Valley, and where income permits an increased supply of fresh milk is obtained. But many people are employed away and return home in the evenings. They get their principal meals away from home on the week days. It is therefore only natural that they help to increase the demand for milk on Sundays. Again children having fresh milk at school may need a supply at home on Saturday and Sunday.

Income per Household and Fresh Milk and Milkstuff purchases.

When households are classified according to incomes the relation between purchases and income per household is brought out. All households and all districts are taken together in the analysis and the summarised results are presented in Table IX.

Income ranged from ten shillings to £10 per household, but most households had incomes ranging from £1—£5. Households with incomes below £1 were few and there was a rapid decline in the number of households in the groups above £5.

No graded milk was purchased in the groups with incomes below £2, and where income was below £1 little fresh milk was purchased and some whole condensed milk, but no other "milkstuff." Skimmed condensed milk was not purchased where incomes were below £1 or above £8; all purchases fall between

TABLE IX.

Average Consumption and Cost of "Milkstuff" per Household.

	Income per Household.										
	Under £1	£1 *and under* £2	£2 *and under* £3	£3 *and under* £4	£4 *and under* £5	£5 *and under* £6	£6 *and under* £7	£7 *and under* £8	£8 *and under* £9	£9 *and over.*	*Whole Group.*
Number of Households	4	178	194	125	55	24	14	4	2	2	602
Persons per Household	1.500	4.034	5.046	5.568	5.254	5.375	4.142	5.250	2.500	3.500	4.830
Fresh Milk :											
Pints	2.375	3.843	6.285	6.496	9.127	8.660	14.321	21.750	5.000	17.500	6.255
Costs (pence)	7.125	11.525	18.885	19.520	28.045	25.979	43.785	67.000	24.000	58.500	18.920
Condensed Milk :											
Pints M.E.	0.937	2.098	2.695	2.771	3.145	3.775	0.321	0.469	—	—	2.520
Costs (pence)	3.625	5.088	6.362	6.968	7.629	10.000	0.642	1.000	—	—	6.140
Milk Powder and Malted Milk :											
Pints M.E.*	—	0.685	0.580	0.644	0.129	1.604	—	—	—	—	0.600
Costs (pence)†	—	0.870	0.744	0.256	1.509	5.187	0.142	—	—	—	0.930
Cream :											
Ozs.	—	1.537	2.551	2.464	1.945	2.937	2.500	2.500	3.500	5.000	2.180
Costs (pence)	—	1.410	2.631	2.368	2.036	3.496	3.535	3.375	9.000	13.500	2.260
Public Supplies of Fresh Milk.											
School—											
‡Number of Children	—	0.236	0.118	0.272	0.145	0.083	0.071	—	—	—	0.180
Pints	—	1.148	0.569	1.260	0.727	0.417	0.357	—	—	—	0.876
Costs (pence)	—	—	—	0.024	—	0.208	0.357	—	—	—	0.025
Clinic—											
Pints	—	0.980	0.752	1.232	0.636	0.291	—	—	—	—	0.860

* Milk Equivalents of Milk Powder only. † Costs of Milk Powder and Malted Milk.

‡ Number of children obtaining milk in schools.

these income levels. Whole condensed milk purchases came between income groups £1—£5 19s. 11d. Milk powder and malted milk purchases fell into income groups £1—£6 19s. 11d. Fresh cream was brought from income group £1 and upwards and tinned cream purchases stop at £7 19s. 11d. Public supplies of fresh milk in schools fell into income groups £1—£6 19s. 11d., and clinic supplies go with households with incomes ranging from £1—£5 19s. 11d.

As household income increased there was an increase in the purchase and average weekly consumption of fresh milk of all grades; there seems to be some connection between income and the grade of fresh milk purchased.

Purchases of whole and skimmed condensed milk increased with increase in income. Two-thirds of the supply of milk powder were free and the purchase of malted milk was so low that a statement of relation to income would be valueless.

Fresh cream was consumed only in small quantities which increased with income per household, but purchases of the tinned variety of cream showed no regular trend. Taking both types of cream together there was a tendency for quantities used to increase with increases in the income of households.

Public supplies of fresh milk were not always given in households with the smaller incomes, but there was a trend towards lower supplies over the whole range of income as income per household increased.

The relation of Income per person, Consumption and Cost of Fresh Milk and "Milkstuff."

This relationship is brought out in Table X. The analysis and summary covers the three districts surveyed, and all households are included. Numbers of persons per household decreased with the increase in income per person, and income generally ranged between 4s. 6d. and 34s. 11d.

The quantity and cost of fresh milk increased through the whole range of income. Consumption and cost of condensed milk increased with increases in income, but more whole condensed than skimmed condensed was purchased in households with the higher incomes per person. The position was not completely reversed in the lower income group, because households unable to purchase fresh milk took the "next best thing." This fact was very clearly demonstrated where supplies of fresh milk from public services were low.

No true relationship between income per person and the purchases of milk powder or malted milk can be established, as

TABLE X.

Average Consumption and Cost of "Milkstuff" per Household.

	Income per Person.								
	Under 5/-.	5/- *to* 9/11.	10/- *to* 14/11.	15/- *to* 19/11.	20/- *to* 24/11.	25/- *to* 29/11.	30/- *to* 34/11.	*Over* 35/-.	*Whole Group.*
Number of Households	17	250	164	76	39	16	20	20	602
Persons per Household	7.353	5.848	4.500	3.776	3.462	3.375	2.900	2.464	4.830
Fresh Milk:									
Pints	3.922	4.939	6.160	7.342	10.050	8.250	9.200	8.844	6.255
Cost (pence)	11.764	14.664	18.725	22.125	30.602	24.875	28.175	28.113	18.920
Condensed Milk:									
Pints M.E.	2.879	3.355	2.800	2.174	0.904	0.890	0.425	0.424	2.520
Cost (pence)	6.764	7.382	6.445	6.264	2.872	3.718	0.775	1.279	6.140
Milk, Powder and Malted Milk:									
*Pints M.E.	1.235	0.994	0.299	0.299	0.045	0.437	0.525	0.071	0.600
†Cost (pence)	—	0.568	1.253	1.329	1.128	1.375	1.125	1.174	0.930
Cream:									
Ozs.	1.411	1.782	2.343	2.526	2.846	2.187	3.000	3.886	2.180
Cost (pence)	1.411	1.572	2.250	2.763	3.627	2.969	3.425	6.255	2.260
Public Supplies of Fresh Milk:									
School—									
‡Number of Children	0.705	0.032	0.042	0.079	0.050	0.062	0.050	—	0.061
Pints	3.530	1.560	0.198	0.329	0.256	0.312	0.250	—	0.876
Cost (pence)	—	0.020	0.015	0.098	—	—	0.250	—	0.025
Clinic—									
Pints	1.647	1.580	0.527	—	0.179	—	—	—	0.860

* Milk equivalents of Milk Powder only. † Costs of Milk Powder and Malted Milk. ‡ Number of children obtaining milk in school.

supplies of the former were mainly obtained from public sources and purchases of the latter were small.

Public supplies of fresh milk at schools and clinics were given, in the main, to school children and other persons from households with low incomes per person. Where there was some deviation from this rule it is due to an uneven distribution in the income groups of school children and other persons receiving milk from public sources. It appears, therefore, that public supplies of fresh milk were given in households with the greatest need.

Consumption and Cost of "Milkstuff" in households purchasing no Fresh Milk.

Households purchasing no fresh milk bought less than the average of condensed milk, but the consumption of milk powder was much higher than the average weekly consumption of milk powder. Purchases of cream, however, were much lower than the average. Fresh milk from public sources was received in large quantities by this group—nearly half the total fresh milk provided in schools, and over half the milk supplied by clinics. While the average number of persons per household in this group

TABLE XI.

Average Consumption and Cost of "Milkstuff" in Households purchasing no Fresh Milk.

Particulars.	*Tonypandy*	*Trealaw.*	*Penygraig.*	*All Districts.*
Number of Households ...	16	48	39	103
Persons per Household ...	5.250	5.541	5.283	5.398
Condensed Milk :				
Pints M.E.	3.476	4.279	3.711	3.969
Cost (pence)	8.843	9.885	9.205	9.466
Milk Powder and Malted Milk :				
Pints M.E. ...	0.437	1.896	1.884	1.665
Cost (pence)	free	free	2.154	0.815
Cream :				
Ozs.	0.750	0.563	1.141	0.820
Cost (pence)	0.562	0.488	1.218	0.757
Public Supplies of Fresh Milk :				
School :				
‖Number of Children	6	31	14	51
Pints	1.875	3.125	1.795	2.427
Cost	—	—	—	—
Clinic : Pints	2.156	2.479	2.807	2.558

‖ Number of children obtaining milk in school

TABLE XII.

Average Consumption and Cost of "Milkstuff" in Households not buying or receiving free supplies of Fresh Milk.

Particulars.	*Tonypandy*	*Trealaw.*	*Penygraig.*	*All Districts.*
Number of Households ..	8	22	11	41
Persons per Household	4.875	4.454	4.090	4.439
Condensed Milk : ...				
Pints M.E.	5.750	4.687	2.988	4.463
Cost (pence) ...	13.937	10.750	7.772	10.573
Milk Powder and Malted Milk :				
Pints M.E. ..	—	—	—	—
Cost (pence)	—	—	—	—
Cream :				
Ozs.	1.500	0.500	—	0.561
Cost (pence) ..	1.125	0.386	—	0.426

was higher than the average for the three districts surveyed, the average quantity of fresh milk from public sources was almost three times as great. This must mean that the receipt of fresh milk in schools and clinics keeps purchases of fresh milk on a lower level or that fresh milk is given in cases of greatest need.

Where free supplies of fresh milk were not given there seems a little tendency to increase purchases and consumption of condensed milks. Milk powder and malted milk were not purchased or consumed at all, and the amount of cream used was trivial.

Consumption and Cost of Fresh Milk and "Milkstuff" in different types of Households.

As there is special need of supplies of milk to children from the points of view of their own welfare and from that of the general public health, records have been analysed for four types of households. These are :—

Group 1 : Households of adult members only.

Group 2 : All households which include children.

Group 3 : Households having children between seven and fourteen years only.

Group 4 : Households having children below seven years only.

Comparisons are drawn between these types and the general group which includes all households. The general trend of consumption and cost of fresh milk and "milkstuff" for this group

has already been dealt with. Households containing adults only were obviously the heaviest purchasers of fresh milk (Group 1). This is particularly striking when the size of household is taken into account. Much less " milkstuff " than the general average was consumed by this group and free supplies from public sources were extremely low. Group 2 purchased less fresh milk, a little more condensed milk, received and purchased more milk powder and malted milk and purchased a little more cream. Public supplies of fresh milk were, of course, much higher. Group 3 shows no appreciable difference from the general

TABLE XIII.

Comparison of Consumption and Cost of Fresh Milk and "Milkstuff" in different types of households.

		Group 1.	*Group 2.*	*Group 3.*	*Group 4.*
	All Households.	*Adults.*	*Adults and Children.*	*With Children. 7-14 years.*	*With Children under 7 yrs.*
Number of Households	602	229	373	144	97
Persons per Household	4.830	3.370	5.726	4.833	5.062
Fresh Milk:					
Pints M.E.	6.255	6.807	6.248	6.421	7.118
Cost (pence)	18.920	19.087	18.833	19.194	20.807
Condensed Milk:					
Pints M.E.	2.520	1.586	3.091	2.284	2.242
Cost (pence)	6.141	4.205	7.651	5.691	5.682
Milk Powder and Malted Milk:					
Pints M.E.	0.600	0.208	0.849	—	1.165
Cost (pence)	0.932	0.973	0.733	—	1.262
Cream:					
Ozs.	2.183	1.984	2.308	2.795	1.958
Cost (pence)	2.257	2.105	2.535	2.917	2.113
Public Supplies of Fresh Milk School Children:					
Number	110	—	110	25	20
Pints	0.876	—	1.414	1.416	0.954
Cost	—	—	—	—	—
Clinic	0.860	0.090	1.328	0.250	1.907

trend of average consumption of fresh milk and " milkstuff " apart from cream. Public supplies of milk at school were slightly more than the figure for Group 2; supplies of fresh milk from clinics were much below that for Group 2. Again the figures for Group 4 show few distinctive

features. Purchases of fresh milk were about normal, and the same is true of other " milkstuff "; purchases of cream were considerably lower than in Group 3. This appears to be partly due to the older children developing a taste for " real " cream. It is more difficult to deceive older children by offering condensed milk in place of tinned cream. Free supplies of fresh milk at school were lower than in Group 3 owing to fewer of these children being of school age and the households larger; free supplies from clinics, however, were high mainly because numbers of expectant and nursing mothers were higher in this group. Babies, as a rule, got free supplies in the form of milk powder and not as fresh milk.

A comparison of consumption and cost of fresh milk and " milkstuff " in the four special groups is shown in Table XIV. There is no common measure of comparison and the best that can be done is to show quantities and cost for fresh milk and " milkstuff," and cream separately.

TABLE XIV.

Comparison of consumption and cost of Fresh Milk and "Milkstuff" (per household and per person).

	All households.	*Group 1.*	*Group 2.*	*Group 3.*	*Group 4.*
Total fresh milk and milkstuff in pints.	11.120	8.193	12.925	10.371	13.381
Cost in pence.	26.003	21.265	27.217	24.885	27.801
Cream (ozs.)	2.183	1.984	2.308	2.795	1.953
Cost in pence	2.257	2.105	2.535	2.917	2.713
Total cost in pence	28.260	26.370	29.752	27.802	29.914
Per person (pence)	5.851	7.825	5.196	5.752	5.909
Free supplies) (pence)	1.077	0.881	1.537	1.035	1.695
Total (pence)	6.928	7.907	6.733	6.787	7.704

Free supplies of fresh milk are included and evaluated in the statement. Group 2 spent least with Groups 3 and 4 ranging about the general average; Group 1 spent most—nearly 8d. per person per week on fresh milk, " milkstuff " and cream. Taking free

supplies of fresh milk into account and giving it a value at 3d. per pint the figures are approximately as follows :—

	Cost per week per person.
	d.
All households	6.9
Group 1	7.9
Group 2	6.7
Group 3	6.8
Group 4	7.7

There was an unmistakeable levelling-up of weekly expenditures per person on milk in all the groups when free supplies were taken into account. The greatest change being in Groups 4, 2 and 3 respectively.

Summary.

The facts presented are representative of the main features of the consumption of milk in the Rhondda Valley, and the three areas surveyed incorporated all the factors likely to affect milk consumption in the whole of the Valley. Milk and " milkstuff " consumption only is dealt with in this study, for quantities of other foodstuffs entering into household supplies of foods have not been ascertained. In the interpretation of the results, however, the existence of these supplies as possible substitutes or possibly complementary foods to milk and " milkstuff " is realised throughout. How far milk and " milkstuffs " compete or are complementary to other foods is not studied here. A survey of the household budgets as a whole would be necessary to discover these facts.

The purchase of fresh milk for human consumption is very low. In some households the quantity consumed is reduced still further by giving purchased supplies to domesticated animals. As a rule this is done mainly in households with the higher incomes. But there are cases where fresh milk is " bought only for the cat."

It appears from the analysis that adults are the heaviest consumers of purchased fresh milk, children consuming far less. It is clear that the " milk-in-schools scheme " is therefore sound in so far as it attempts to develop a milk habit in those households having the lowest quantity of fresh milk. Necessitous cases get free fresh milk in schools and clinics. In the majority of cases free supplies are given to households with the greatest number of people.

Purchases of fresh milk increase with increases in income *per capita*, though the increase is not regular. Where income is

least, free supplies of fresh milk are greatest. Quantities vary but the general tendency for purchased and free supplies of fresh milk to balance each other is unmistakable. Income *per capita* tends to be low where the number of persons per household is high, for it must be remembered that income per person is a resultant of money earned divided by persons per household. Without stretching the point in any way it may be stated that large households have the lesser chance of purchasing as much milk as they need. Free supplies therefore must supplement purchases.

In households where there is a desire for regular supplies of fresh milk restriction of income occasionally prevents the purchase of fresh milk for short periods at a time. When such periods extend for a week or more an immediate return to previous habits is not made. Owing to the existence of other calls on income attempts are made to prolong the period before fresh milk is again purchased. This period often extends to a month and perhaps more before purchases return to normal. In essence this means that there is a lag between increases in milk purchases and increases in income but an immediate drop *in fresh milk purchases with falls in income*. It appears, therefore, *that an all-round increase in income would take some time to make itself felt* on fresh milk purchases particularly in those households where the appreciation and valuation of milk as a food is low.

The variation in week-end purchases of fresh milk is partly accounted for by the return over week-ends of members working away from home. Extra supply is needed to meet the demand made by these people. A part of the extra supply, however, is made into milk puddings. *One of the best methods of increasing the consumption of milk* would be an extension of this week-end milk pudding habit to other days of the week. Coal miners, however, work varying shifts, morning, afternoon or evening, and often it is by no means a simple matter to arrange for milk puddings to be made even where *purchasing power is* available. Still some extension of this *dietary habit is possible* and desirable.

Apart from the fresh milk that is made into puddings most of it is used for colouring beverages. Little fresh milk is consumed in the raw or heated state. Almost the only households to consume milk in this way are a few of those having high incomes *per capita* and in households where there is sickness.

It is sometimes stated that there is a possibility of increasing fresh milk consumption by diverting the demand for condensed milks and milk powders to the fresh milk market. While this statement is perfectly true as it stands the methods or method by which this diversion is to be attained is not at all clearly stated. This study indicates a very regular relationship between the purchases of fresh milk and other types of milk. While the purchases of condensed milk rise with increases in income *per capita* this relationship is not quite so striking as in the case of fresh milk. Moreover purchases of condensed milk blend in with purchases of fresh milk. Where households can still get some fresh milk a supply of skim condensed is bought also. When no fresh milk is bought mostly whole condensed is bought with some skim condensed. Householders buy what is, in their judgment, the best combination of milks. Considerations of convenience as well as nutrition enter into these judgments.

Adults and children in many households prefer the flavour of condensed milks. Many go so far as replacing jam with condensed milk and again in beverages a particularly strong bias exists in its favour. More than this it is more economical in the sense that it lasts much longer than the quantity of fresh milk purchased at equal cost. Again coal miners rising early for work prepare a hot beverage long before the milkman arrives and a supply of fresh milk left over-night often turns sour. So long as fresh milk is delivered loose or in bottles it is practically certain that the increase obtained by attempting to direct customers to replace condensed milk with fresh milk will be very small indeed. Dietary habits of long standing will not be easily broken particularly when the products on which such habits depend are the cheaper or more economical.

Taking the supplies of fresh milk, condensed milk, milk powder and malted milk together there is an unmistakable blending of total supplies. Attempts to increase the supplies of one type at the expense of the others will succeed only to a very limited extent.

The consumption of fresh cream is low. In the main it enters into consumption only in relatively well-to-do households and even then far more of it is used in the summer than any other season. More tinned cream is used but the consumption of this variety is still relatively low. One of the main reasons for the low consumption of cream is its cost; people with low incomes cannot afford to purchase it. Moreover, when extra

purchases of fresh milk are made at the week-end and part of these are made into custard and similar puddings there is less opportunity for cream to enter into consumption.

Purchasing power is the main factor influencing the purchase of all milks. From the figures collected and the statements made to surveyors it is reasonable to expect a higher consumption of all milks with :—

(a) Increase in incomes
(b) Decrease in price of milks
(c) Combination of (a) and (b).

Increase in purchasing power will not be devoted entirely or immediately to the purchase of milks; some will go to obtain other satisfactions.

Any extra money spent on milk will be distributed between fresh milk and other " milkstuff " owing to the existence of :—

(a) Strong dietary habits
(b) Reasons of occupation and mode of life.
(c) Attempts to blend milk purchases to get the greatest satisfaction from purchases.

Given higher purchasing power, increase in the demand for fresh clean milk can best be obtained by establishing a much stronger and sounder appreciation of the value of fresh milk among housewives. This can be done by educating people to appreciate the value of fresh milk in nutrition and in protection against diseases. Explanation of better methods of handling milk in the home would also be very useful and demonstrations of the use of fresh milk for cooking would perhaps induce many to extend their week-end habits of fresh milk purchases to other days of the week. The various methods of educating and persuading those people who consume little or no fresh milk should be developed and applied directly.

In such areas as the Rhondda Valley there is special need of methods of packing fresh milk in some sort of non-returnable carton. Small cartons for packing small quantities of fresh milk would be useful. Apart from the present tendency to buy goods in small amounts, this would assist people needing only a small supply of fresh milk very early in the morning or very late in the evening. The chances of wastage and sourage would be very much reduced as well as the work and uncertainty of washing bottles and jugs.

An extension of the " milk-in-schools scheme " to collieries, factories and large shops and the establishment of fresh milk " bars " would be steps in the right direction. This would go

some distance, at least, towards maintaining the "fresh milk habit" set up in schools.

The work of milk publicity should be continued, extended and intensified. No amount of study should be spared in directing publicity to the weak links in fresh milk consumption in specific districts. Mere general treatment of the problem is of very limited value.

The principle of multiple prices for fresh milk needs to be exploited to the utmost. It is true that this type of price-fixing needs very careful control, but in depressed areas an intelligent use of multiple prices for fresh milk will provide foundations for increase in consumption. When this is done publicists can at least feel far more justification in pushing the purchase of fresh milk much more than has been done in the past.

QUANTITIES AND VALUE OF FARM PRODUCE CONSUMED IN THE FARM HOUSE.

By J. PRYSE HOWELL, M.Sc.,
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The farmer's family receives directly from the farm a considerable part of its support in the form of food, fuel and shelter. These supplies enable many farm families to live reasonably well even in times of depression and afford to them a sense of security as regards provision for primary needs which is not obtained by the city industrial worker living on the same income level. The common description of produce consumed is that of "farm privileges", but although they are secured without direct cash payment they are not obtained free of cost, for labour and capital have been employed in their production.

From the farm accounts kept by the Department[1] it has been possible to extract some data pertaining to the quantities and value of home-grown produce consumed in the farm house, giving some idea of the extent to which the cash living expenses of the farmer and his household are reduced by the produce obtained from the farm. These results cover a period of five years. The values of the farm produce consumed has been

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[1] Department of Agricultural Economics, University College of Wales, Aberystwyth.

assessed at the market price received by the farmer for similar products sold. These values are lower than the retail price of foodstuffs of a similar nature if bought by the farmer's wife at a shop or store. In the case of some of the products, the difference between farm and retail price is considerable, in others the margin is fairly small. The farm prices for each class of foodstuff are given in Table I and some retail prices in Table II, but these prices are not strictly comparable. The retail prices probably represent what the farmers' wives would have paid for the commodities had they been bought in shops. But it does not follow that the qualities of the produce represented by the two sets of prices are exactly equal. The first inclination of external judges may be towards the statement that the home produce is superior. On the other hand, there is experience that farm families somewhat more prosperous than those dealt with turn rather more towards purchased goods, especially in some classes. These families are not exercising entirely free choices in consumption. They would lose financially to some extent by sale of goods hitherto consumed and the purchase of similar or equivalent goods, and they cannot afford the expenditure for the goods which they might obtain by choice. This is almost certainly one of the big factors in determination of the high consumption of pig-meat and potatoes. In essential qualities, some produce consumed is poorer than that commonly offered in reasonably good shops, while some is undoubtedly better. Certainly some of the produce consumed is not equal to the produce sold from the same farms. On balance, probably, there would not be a great difference in the essential qualities of the home produce and purchased goods.

Comparison of the figures given in Table I and II show that in certain years the difference between farm and retail price of milk varied from 9d. to 13d. per gallon and in the case of butter from 3¼d. to 7d. per lb. Lower margins are noticeable in cheese prices and the variations were from 1¼d. to 3¾d. per lb. Differences between farm and retail prices of eggs are fairly wide and vary from 7½d. to 10¼d. per dozen. Retail prices are stated for 'British' legs of mutton, frozen mutton and 'streaky' bacon, while farm prices are given for sheep and pigs on a 'per head' basis. The price per lb. was arrived at by allowing carcass weights which were known to be fairly representative for the farms under consideration. For that reason, the farm price which is based on total carcass weight per lb. is lower than would have been the case had it been possible to arrive at the

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farm price of mutton and bacon on the same basis as that adopted for retail prices. The margin between farm and retail price of mutton and bacon would therefore be less than indicated by the figures for these commodities.

TABLE I.

Farm Prices of Produce Consumed.

Commodity.	*1929-30.*	*1930-1.*	*1931-2.*	*1932-3.*	*1933-4.*	*All Years.*
Oats (per cwt.) ...	8s. 8d.	8s. 10d.	8s. 0d.	7s. 11d.	8s. 0d.	8s. 3d.
Milk (per gallon)	14.5d.	12.2d.	12.8d.	14.9d.	13.0d.	13.2d.
Butter (per lb.)	18.1d.	13.3d.	14.1d.	12.6d.	11.7d.	13.7d.
Cheese (per lb.)	12.8d.	9.3d.	7.5d.	8.1d.	7.0d.	9.4d.
Potatoes (per cwt.) ...	4s. 8d.	4s. 0d.	4s. 9d.	4s. 2d.	3s. 0d.	4s. 1d.
Eggs (per dozen)	16.8d.	13.8d.	13.4d.	13.2d.	12.1d.	13.5d.
Poultry (per head)	34.9d.	42.1d.	43.7d.	36.8d.	35.2d.	39.3d.
*Poultry (per lb.)	9.9d.	12.0d.	12.5d.	10.5d.	10.0d.	10.1d.
Pigs (per head) ...	£8 5 8	£8 9 7	£6 8 2	£6 3 2	£5 12 8	£6 16 1
*Bacon (per lb.)	9.9d.	10.1d.	7.6d.	7.3d.	6.7d.	8.1d.
Sheep (per head) ...	£1 6 10	£1 16 10	£1 2 4	£0 16 10	£0 18 4	£0 19 5
*Mutton (per lb.)	8.2d.	11.6d.	7.0d.	5.3d.	5.7d.	6.1d.

* Estimating deadweight of Poultry at 3½ lb. per head.
Estimating deadweight of Pigs at 200 lb. per head.
Estimating deadweight of Sheep at 38 lb. per head.

TABLE II.

Retail Prices of Foodstuffs (Ministry of Labour Gazette).

Commodity.	*1929.*	*1930.*	*1931.*	*1932.*	*1933.*
	Pence.	*Pence.*	*Pence.*	*Pence.*	*Pence.*
Milk (per gallon)	25.0	25.0	24.0	24.0	24.0
Butter (per lb.)	23.5	20.3	17.3	16.0	14.3
Cheese (per lb.)	14.0	13.0	10.7	10.5	9.5
Eggs (per dozen)	27.0	24.0	21.0	21.0	18.0
Mutton (British Legs) per lb. ...	18.2	18.0	17.0	15.5	14.5
Mutton (Frozen) per lb.	11.7	11.5	10.5	9.5	9.2
Bacon (Streaky) per lb.	17.5	16.0	11.5	10.0	11.5

Table III shows the value of the produce actually produced on the farm and consumed in the house over a period of five years.

Milk was the only product that was consumed on every farm and taking one year with another, this item was responsible for about 25 per cent. of the total value of the farm produce used. Owing to the importance of milk sales on some

farms, these relied entirely on supplies of purchased butter and while this was the case, the consumption of farm butter amounted to more in value than consumption of milk in the first three years. In the last two years, however, it was less in value than the milk consumed. Over all years farm butter represented about 23 per cent. of the total value of the farm produce used by the family. Only a small percentage of the

TABLE III.

Value of Farm Produce Consumed in the Farm House.
Average over All Farms each year.

Year	*1929-30.*			*1930-1.*			*1931-2.*			*1932-3.*			*1933-4.*		
Number of Farms	36			50			62			67			61		
	Per Farm.			*Per Farm.*			*Per Farm.*			*Per Farm.*			*Per Farm.*		
Commodity.	*£*	*s.*	*d.*	*£*	*s.*	*d.*	*£*	*s.*	*d.*	*£*	*s.*	*d.*	*£*	*s.*	*d.*
Milk	13	7	4	9	19	8	9	17	5½	10	7	0	8	16	6
Butter	14	6	4	10	16	2	9	17	6	7	18	6	7	4	9
Cheese	1	15	11	0	12	6	0	8	9	0	6	8	0	7	1
Eggs ...	3	16	7½	4	7	2	3	17	9	3	15	2	3	11	2
Poultry	2	7	5½	3	17	1	2	18	6	2	7	2	3	1	9
Pigs	12	17	9	12	9	3	8	7	5	8	9	2	9	0	0
Sheep	0	5	11½	0	8	1	0	14	2½	1	6	11	1	2	0
Potatoes	3	16	11½	3	9	7	4	5	8	3	0	4	2	7	6
Oats	0	5	5½	0	6	1	0	0	8½	0	6	1	0	2	9
Total	52	19	9½	46	5	7	40	7	11½	37	17	0	35	13	6
Number of Persons	5.8			5.3			5.2			5.1			5.1		
Men Equivalents	4.4			4.4			4.4			4.3			4.3		

farms made cheese; but taking milk, butter and cheese together these were responsible for about 50 per cent. of the value of the total farm products made use of in the households. Practically all the farms consumed home produced eggs but while fewer farms made use of poultry these two items combined had a significant value on the majority of farms. On an average over 80 per cent. of the holdings made use of home-cured bacon while only a small percentage relied on home killed mutton. As might be expected the use of home grown potatoes was fairly general while the utilisation of oats for oatmeal was the exception rather than the rule.

The total value of the farm produce consumed in 1929-30 was £52 19s. 9½d. per farm or slightly over £1 per week. Each year showed a decline in value and in 1933-4 the quantity consumed from the farm only amounted in value to £35 13s. 6d.

per farm or 13s. 8d. per week. This decline was mainly due to the fall in prices of farm produce as the quantities of farm produce consumed and the number of persons per farm remained fairly constant from year to year. The average size of the farm family including servants boarded-in only varied from 5.1 to 5.3 per farm or when expressed in terms of man equivalents[2] the variation was from 4.3 to 4.4 men per farm.

In considering these farm privileges it must not be overlooked that apart from the value of the food consumed, the farmer does derive some other economic advantages. In these calculations nothing has been allowed for the rent of the farmhouse and no allowance has been made for the value of vegetables and fruit supplied from the farm garden. Again, available supplies of farm timber and peat for fuel assist in reducing the living expenses of the farmer. Rental value of farm houses averaged about £12 per farm and £5 per farm can be regarded as a fair estimate for the value of garden produce and fuel. Thus, £17 per farm can be allowed as an additional amount of consumption values, equal to income, obtained from the farm. When this amount is added to the value of the farm produce consumed the result is as follows :

Averages over All Farms.

Year.	*Value of Farm Produce Consumed.*	*Value of House, Garden Produce and Fuel.*	*Total.*
	Per Farm. £ s. d.	*Per Farm.* £ s. d.	*Per Farm.* £ s. d.
1929-30	52 19 9½	17 0 0	69 19 9½
1930-1	46 5 7	17 0 0	63 5 7
1931-2	40 7 11½	17 0 0	57 7 11½
1932-3	37 17 0	17 0 0	54 17 0
1933-4	35 13 6	17 0 0	52 13 6

When the annual residential value of house, values of garden produce and fuel are included the advantage to the farmer in the cost of living expenses was about £70, or approximately 27s. per week in 1929-30. By 1933-4 this was reduced to £52 13s. 6d. or slightly over £1 per week.

Converting these values into terms of man equivalent per farm the value of farm produce consumed per man per annum

[2] Men (over 14) = 1.0
Women (over 14) = 0.8
Children (under 14) = 0.5

was £11 19s. 11d. or about 4s. 7d. per man per week, while in 1933-4 it amounted only to £8 5s. 9d. per man per annum, or 3s. 2d. per week per man.

Per Man Equivalent.

Year.	*Value of Produce Consumed.*	*Value of House, Garden Produce and Fuel.*	*Total.*
	£ s. d.	£ s. d.	£ s. d.
1929-30	11 19 11	3 17 2	15 17 1
1930-1	10 11 7	3 17 2	14 8 9
1931-2	9 3 3	3 17 2	13 0 5
1932-3	8 14 0	3 19 0	12 13 0
1933-4	8 5 9	3 19 0	12 4 9

Adding rent of house, fuel and garden produce brings the figure up to £15 17s. 1d. per man per annum or 6s. 1d. per man per week in 1929-30 and £12 4s. 9d. per man per annum or about 4s. 8d. per man per week in 1933-4.

Milk was consumed on all the farms but such was not the case as far as other farm produce were concerned. For that reason it is necessary to show the quantites and values of farm produce for those farms actually consuming the product; and the data for milk, butter and cheese is given in Table IV.

From the data it appears that the farms in the first period of the investigation consumed higher quantities of milk as the milk consumed gradually declined from 220 gallons per farm and 50 gallons per man per annum in 1929-30 to 163 gallons per farm and 38 gallons per man per annum in 1933-4. Over the whole period the consumption of milk was 186 gallons per farm and 43 gallons per man per annum. This gives an average annual consumption per "man" of 344 pints or 0.94 pints per day.

When the consumption of milk for these farms is expressed on a *per person* basis it is found that over the whole period the average consumption was 36 gallons per annum. This gives an annual consumption of 288 pints or a daily allowance of 0.78 pints per person. Estimates of consumption amongst the general population have varied between 0.3 and 0.4 pints per day with a somewhat general average of 0.33 pints per day.[3] As might be expected, larger quantities of milk are consumed on the farms per person than is found to be the case for the

[3] Ministry of Agriculture and Fisheries. Economic Series No. 38.

whole country and the results indicate that the daily farm consumption was higher by about one-fourth of a pint per person than that found for "good middle class" families in the City of Cardiff.[4]

The consumption of farm butter varied in the different years from 187 lb. to 229 lb. per farm and from 44 to 52 lb. per man. The average consumption over the whole period was

TABLE IV.

Milk, Butter and Cheese (per Farm and per Man). Averages over Consuming Farms.

	Farms consuming Product.	*Per Farm.*		*Per Man Equivalent.*	
		Quantity.	*Value.*	*Quantity.*	*Value.*
Milk.	*No.*	*Gallons.*	*£ s. d.*	*Gallons.*	*£ s. d.*
1929-30	36	220	13 7 4	50	3 0 6
1930-1 ...	50	197	9 18 8	45	2 5 8
1931-2	62	185	9 17 5	42	2 4 9
1932-3	67	182	10 7 0	42	2 7 7
1933-4	61	163	8 16 6	38	2 1 0
Average	—	186	10 4 8	43	2 6 10
Butter.		*lb.*		*lb.*	
1929-30	31	220	16 12 6	50	3 15 0
1930-1	43	228	12 11 4	52	2 17 4
1931-2	52	200	11 15 5	50	2 18 5
1932-3	54	187	9 16 8	44	2 5 11
1933-4	46	197	9 11 11	47	2 5 6
Average	—	204	11 13 8	48	2 14 11
Cheese.		*lb.*		*lb.*	
1929-30	9	135	7 3 8	29	1 10 9
1930-1 ...	11	73	2 16 10	18	0 13 6
1931-2	11	79	2 9 3	19	0 12 0
1932-3	14	47	1 11 11	11	0 7 6
1933-4	15	49	1 8 8	12	0 7 1
Average	—	71	2 15 8	17	0 13 2

204 lb. per farm and 48 lb. per man. According to estimates[5] made the annual *per capita* consumption of butter in Great Britain was 15.4 lb. in *circa* 1924 compared with 15.8 lb. before the war and in 1931 at 21 lb. In 1932 the *per capita* consumption was estimated at $21\frac{3}{4}$ lb. (See Table VIII). The *per capita* consumption of the farms under review over the period 1929-34 was 39.9 lb. or slightly over 8 lb. more per person than that estimated as consumption of butter in Great Britain in 1932.

[4] The Consumption of Milk in Cardiff. Jones and Cowie. This *Journal*, Vol. X. (1934).

[5] Ministry of Agriculture and Fisheries. Economic Series No. 30.

The farm consumption of butter allows for slightly over ¾ lb. of butter per person per week.

The consumption of home produced cheese is not very general. Something like 20 per cent. of the farms made use of farm-made cheese. The quantity consumed shows considerable variation from year to year. In 1929-30 home made cheese consumed was 135 lb. per farm and 29 lb. per man while in 1932-3 it only amounted to 47 lb. per farm and 11 lb. per man per annum. For the five years (1929-34) the average annual consumption was 71 lb. per farm and 17 lb. per man. When the total number of persons is taken into consideration, the average annual consumption was 14.6 lb. per person per annum, or put in another way, each person consumed on an average approximately one-third of a lb. of cheese each week. This is about 5 lb. more than the estimated consumption for Great Britain which is stated as 9.5 lb.[6] per person per annum.

The returns for the farms consuming poultry and eggs are given in Table V.

TABLE V.

Poultry and Eggs (per Farm and per Man).

Averages over Consuming Farms.

	Farms consuming Product.	*Per Farm.*		*Per Man Equivalent.*	
		Quantity.	*Value.*	*Quantity.*	*Value.*
Poultry.	No.	No.	£ s. d.	No.	£ s. d.
1929-30 ...	24	21.5	3 11 2	4.9	0 16 4
1930-1 ...	43	25.6	1 9 8	6.0	1 1 3
1931-2 ...	50	19.3	3 12 7	4.3	0 16 3
1932-3 ...	57	18.0	2 15 5	4.3	0 13 2
1933-4 ...	54	23.8	3 8 6	4.9	0 14 7
Average ...	—	21.6	3 10 9	4.8	0 16 0
Eggs.					
1929-30 ...	35	674	3 18 10	151	0 17 7
1930-1 ...	50	907	1 7 2	207	0 19 11
1931-2 ...	62	835	3 17 9	189	0 17 8
1932-3 ...	66	834	3 16 3	193	0 17 7
1933-4 ...	59	880	3 13 8	208	0 17 4
Average ..	—	837	3 18 5	192	0 18 0

It might have been expected that the farm consumption of poultry would have been higher. The highest figure recorded (1930-1) did not allow for more than one bird every other week

6 Ministry of Agriculture and Fisheries. Economic Series No. 22, p. 38.

or an annual allowance of six birds per man. The average consumption was 21.6 birds per farm and 4.8 per man. Assessing the poultry at 3½ lb. each, the consumption of home produced poultry was on an average 16.8 lb. per man per annum. When expressed in terms of persons the annual consumption is 4.2 head of poultry or 14.7 lb. per person. Estimates[7] for Great Britain give a consumption of between 3½ to 5lb. per person and if the figure of 5 lb. is taken it means that the consumption of home produced poultry on these farms is about three times as much as that estimated for Great Britain.

Consumption of eggs varied from 674 to 907 per farm and from 151 to 208 eggs per man per annum. An average for the five years gives an annual consumption of 192 eggs per man and 162 eggs per person. If the latter figure is taken it means that each person in the farm household uses less than one egg every other day. When compared with estimates[8] for Great Britain, which give a *per capita* consumption of 162 eggs in 1929, 179 in 1931 and 166 in 1933, the consumption of eggs on these farms appears to be low. One would have expected that, taking into consideration the high nutritive values of eggs, more prominence would be given to them in the farm diet.

The farm consumption of pigs and sheep is given in Table VI.

TABLE VI.

Pigs and Sheep (per farm and per Man).
Averages over Consuming Farms.

	Farms consuming Product.	*Per Farm.*		*Per Man Equivalent.*	
		Quantity.	*Value.*	*Quantity.*	*Value.*
Pigs.	No.	No.	£ s. d.	No.	£ s. d.
1929-30	31	1.8	14 19 4	0.4	3 6 10
1930-1 ...	41	1.8	15 3 9	0.4	3 11 1
1931-2	50	1.6	10 3 7	0.4	2 8 9
1932-3	52	1.8	10 17 11	0.4	2 10 5
1933-4 ...	52	1.8	10 11 2	0.4	2 8 5
Average	—	1.8	12 0 10	0.4	2 15 7
Sheep.					
1929-30	4	2.0	2 13 9	0.4	0 9 11
1930-1	9	1.2	2 4 9	0.3	0 11 2
1931-2	17	2.3	2 11 11	0.4	0 9 8
1932-3	27	3.9	3 6 7	0.9	0 14 5
1933-4	20	3.6	3 7 1	0.8	0 14 8
Average	—	3.1	3 0 3	0.6	0 17 6

[7] Ministry of Agriculture and Fisheries. Economic Series No. 42.
[8] Ministry of Agriculture and Fisheries. Economic Series No. 42.

Consumption of home killed bacon remains practically constant in each year and averages over the whole period 1.8 pigs per farm and 0.4 pigs per man. Allowing a carcass weight of 200 lb. per pig the farm consumption of pig meat is 80 lb. per man per annum or a daily allowance of 3½ ounces. Per person the annual consumption is 68 lb. or nearly 3 ounces per person per day. Farm consumption of pig meat is considerably higher than the estimates[9] for the whole country which give a figure of 35 lb (pre-war) and slightly under 44 lb. of pig meat in 1924 per person per annum.

While it is the custom on some farms to kill a sheep or two, for household use, this does not represent the total quantity of mutton consumed during the year. Home supplies are only part of total consumption. The average for these farms gives the consumption of home supplies at 3.1 sheep per farm and 0.6 sheep per man. Allowing carcass weights of 38 lb. per sheep the annual consumption of home killed mutton is 20 lb. per man and 23 lb. per person.

Farm consumption and value of home produced potatoes and oats is given in Table VII.

TABLE VII.

Consumption of Potatoes and Oats (per Farm and per Man), Averages over Consuming Farms.

	Farms consuming Product.	*Per Farm.*		*Per Man Equivalent.*	
		Quantity.	*Value.*	*Quantity.*	*Value.*
Potatoes.	*No.*	*cwt.*	£ s. d.	*cwt.*	£ s. d.
1929-30 ..	27	21.8	5 2 7	4.7	1 2 1
1930-1 ...	43	20.2	4 0 11	4.4	0 17 6
1931-2 ..	56	19.8	4 14 10	4.3	1 0 9
1932-3 ...	63	15.3	3 4 2	3.4	0 14 4
1933-4 ...	54	17.7	2 13 8	3.9	0 12 0
Average ...	—	18.1	3 16 2	4.0	0 16 9
Oats.		*lb.*		*lb.*	
1929-30 ...	4	633	2 9 2	155	0 12 1
1930-1 ...	6	639	2 10 4	138	0 10 11
1931-2 ...	8	207	0 14 10	59	0 4 3
1932-3 ...	5	1,159	4 2 0	245	0 17 4
1933-4 ...	3	787	2 16 2	186	0 18 3
Average ...	—	721	2 13 5	167	0 12 4

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[9] Ministry of Agriculture and Fisheries. Economic Series No. 12.

The potatoes consumed vary from about 17¾ cwt. to nearly 22 cwt. per farm and from slightly less than 3½ cwt. to about 4¾ cwt. per man. The average quantity used for farm house consumption was approximately 18½ cwt. per farm or 4 cwt. per man per annum. The actual consumption per person over the whole period is 3.4 cwt. or 381 lb. per annum. This allows for a daily consumption of slightly over 1 lb. per person. Estimates made appear to suggest that farm consumption is about twice as much as the *per capita* consumption for Great Britain. [10, 11]

Only a small percentage of the farms utilised home produced oats for household purposes. It is probable that, in addition, purchases of oatmeal were also made. The total supplies for farm consumption are possibly higher than those indicated by these figures. Home supplies showed a variation of between 207 lb. and 1,159 lb. per farm or between 59 lb. and 245 lb. per man per annum. For each person the annual consumption of farm supplies was 140 lb. or a weekly allowance of nearly 2¾ lb. per person.

For some items of food the farm household relies entirely on home supplies. For these particular farm products it is possible to compare the *per capita* consumption on farms with the estimates given for Great Britain. This is done in Table VIII.

TABLE VIII.

Per Capita Consumption for Great Britain[11] and on Farms using Product.

	Britain.				*Farms consuming product.*
	1924-27.		*1932.*		*1929-34.*
Milk (gallons)	16.0		18.5		36.0
Butter (lb.)	15.5		21.75		39.9
Cheese (lb.)	9.5		9.75		14.6
Eggs (no.)	113.0		150.0		162.0
Potatoes (lb.)	187.0		200.0		381.0
Poultry (lb.)	3.75		5.0		14.7
Bacon (lb.) ...	20.5	37.0	30.0	47.0	68.0 (Pig Meat)
Ham (lb.)	4.0		3.0		
Pork (lb.)	12.5		14.0		
Mutton and Lamb (lb.)	25.5		30.5		—
Beef and Veal (lb.)	69.5		62.5		—

[10] Ministry of Agriculture and Fisheries. Economic Series No. 34.
[11] Feavearyear, A. E. "The National Expenditure." *The Economic Journal*, Vol. XLIV, No. 173.

The consumption of all dairy produce is considerably higher than that estimated for the whole of the country and in this respect the farm diet shows a decided advantage. Strangely enough, eggs do not appear to be more generally used in farm families than among other people at large. Potatoes is one of the foods of which rural families might be expected to show higher consumption than those in town and the quantities consumed on the farms shows this to be the case. Complete figures for meat are not available, but if the consumption of bacon, ham and pork are taken to represent all pigmeat consumed, the farm consumption exceeds the general average consumption for the country in 1932 by 21 lb. per person. In the case of poultry, consumption on the farms is about three times that of the general population. Pigmeat and poultry together show an average consumption on the farm of 82.7 lb. per person. Farm consumption of meat would be augmented by supplies of beef and mutton, but generally pork products and poultry have long been the commonest kinds used in rural areas, and the farm families probably still depend chiefly on farm supplies of pigs and chickens which they can produce at less cost than other meats bought from the butcher. It is probable that pigmeat and poultry represent something like three-fourths of the total meat consumption on farms. If an extra one-fourth is added this

TABLE IX.

Value of Farm Produce Consumed, Rent of House, Garden Produce and Fuel.
(Average All Years, 1929-34).

	Per Farm.	*Per Man.*	*Per Person.*	*% to Total.*
	£ *s.* *d.*	£ *s.* *d.*	£ *s.* *d.*	%
Foods	41 8 11	9 9 10	8 0 3	70.9
Rent	12 0 0	2 14 9	2 6 5	20.5
Garden Produce and Fuel	5 0 0	1 2 11	0 19 4	8.6
Total	58 8 11	13 7 6	11 6 0	100.0

would bring the annual consumption of meat on farms up to 110 lb. per person or a daily allowance of about 4½ oz. per person. Estimates made appear to indicate that the *per capita* consumption for all meats in Great Britain is somewhere between 145-150 lb. per person or a daily allowance of about 6¼ oz. per person.[12].

[12] Ministry of Agriculture and Fisheries. "The Agricultural Output and the Food Supplies of Great Britain."
Ministry of Agriculture and Fisheries. Economic Series No. 39.

The family living from the farm enables the farmer to reduce the cash cost of living and to tide over lean years and hard times that would be ruinous if he had to buy all the living for himself and family on the market. Over the whole period (1929-34) if an allowance is made for rent of house and value of garden produce and fuel these farm privileges averaged £58 8s. 11d. per farm or about 22s. 6d. per week.

Foods from farm crops and stock made up approximately 71 per cent. of the family living from the farm and were it necessary to buy all food furnished by the farm at retail prices, the cost would be fully 50 per cent. above farm prices on which the value of farm foods is based.

Important as the family living from the farm is, it must not be overlooked that this living is not obtained entirely free of cost to the farmer. Should the produce of farm crops and stock which is consumed be of equal quality to that sold, it must be presumed that the farmers concerned could have increased their cash incomes to the extent of nearly £41 10s. 0d. per annum by selling the goods. Also, on the presumption of equal quality, the unit costs of produce consumed are equal to those of produce sold. The economy of home consumption of farm produce is of complex character. It has not to be fetched from shop or store and each kind is readily available during its own season and some at all seasons. There are no distributors' services to be paid for and in some cases, as with eggs, milk, or potatoes equal satisfaction is obtained from one unit of home produce consumed as from a purchased unit of the commodity. On the other hand, there is some tendency to consume produce of slightly lower marketable value than that which is sold. Potatoes of unattractive shape or appearance, eggs of ill-shape or unsatisfactory shell, one of the pigs which will appear less attractive than others on the markets, possibly a sheep which has had a slight accident, offer possibilities of economy when their defects are only those of appearance. But it would be unwise to assume that farm families get full consumers' satisfactions from the home produce which they use, because this is to assume that they would not make changes with wider opportunities of choice, while it is almost certain that such changes are made when opportunities occur. Study of general dietaries of these farms would yield useful information, but it appears probable that the only comparative advantages in nutrition arising from consumption of home produce, as compared with the average dietary of the

population, may be that arising from greater consumption of milk, and possibly of butter. The great economy in consumption of home produce arises from the saving of distributors' costs on part of the food supplies, but some of this saving has to be discounted by loss of consumers' satisfactions through economic and geographical (distance) enforcement of choice. If a wider choice of consumers' goods were taken into consideration it is probable that disadvantages in obtaining goods other than foods would also tend to balance farmers' advantages in obtaining supplies of limited classes of foodstuffs. Yet as foodstuffs are primary there is a kind of primitive advantage in the security of some supplies.

THE PRODUCTION AND MARKETING OF MARKET GARDEN PRODUCE IN THE ABERYSTWYTH AREA.

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During the period of economic depression many farmers have shown increasing interest in the production and sale of vegetables and fruit. Since the Horticultural Produce (Emergency Customs Duties) Act, 1931, and the Import Duties Act, 1932, came into force this interest has been intensified, with consequent development and spread of production.[1] It would appear, however, that there has been less development of the " horticultural " industry on farms of Wales than on those of other parts of the country. This is probably the case, but it is exceedingly difficult to obtain any accurate measure of the farm production of vegetables and fruit for sale, or of its increase, in Wales. A survey of sale and consumption of eleven commodities (vegetables, fruits and salad crops) made in thirteen towns of North Wales for the years 1931-32 revealed a much higher consumption of local grown produce than had been expected, and the information on local supplies showed more widespread and highly developed production than had previously been realised.[2] It now appears probable that the production of vegetable crops for market is more prevalent and widespread in the coastal areas of Wales than has hitherto been revealed by any published records.

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1 See *Journal of Ministry of Agriculture*, Vol. XL, No. 10. (Jan., 1934).
2 Report on Possible Development in Horticulture of North Wales. North Wales Horticultural Committee, University College, Bangor. (1934).

Following the survey of consumption and, incidentally, of local production of vegetables and fruit in North Wales it seemed desirable that some attention should be paid to production in the Aberystwyth area of Cardiganshire. It was known, generally, that a number of farmers were financially interested in the production of vegetables—and some fruit—for market, and the great majority of these farmers had been growing market garden crops before 1931.

(1) Crops produced in Aberystwyth area.

The area of the survey may be described as that of farms lying within six miles of Aberystwyth at an altitude of not more than 800 feet above sea-level, but it was found necessary to make one or two exceptions and one farm is situated at fifteen miles distance in the direction of Tregaron. The method of discovery adopted was that of collecting names and addresses of farmers known to be selling one or more market garden crops in Aberystwyth, but the farmers who sold only potatoes were not asked for information. Visits were paid to fifty-six farmers who occupied fifty-eight holdings. The total area occupied was 3,881 acres, making an average of about sixty-seven acres per holding, and sixty-nine acres per farmer. The average size of "holding" in the county is a little over seventy-one acres when rough grazings are included.

According to the *Agricultural Statistics* the area of land in Cardiganshire holdings of over one acre under certain vegetable crops has not exceeded sixty-three acres during the previous ten years, but some thirty-nine acres of these crops were found on the fifty-six farms under survey.

Areas under Certain Crops in Cardiganshire 1924-1932.
(Acres).

	1924.	*1933.*	*Highest.*	*Lowest (of years with crop).*
Cabbages, sprouts, cauliflowers and broccoli	7	20	22	7
Beans and peas	—	34	47	16
Carrots	5	8	9	8
Onions, celery and rhubarb	—	—	2	1
Total	12	62	63*	12*

* Highest and lowest gross totals in single years.

On the other hand, only a very small area of the farms surveyed was under " small fruit " (raspberries, strawberries, currants and gooseberries) while the total shown for the county has varied from twenty-four or twenty-five acres ten years ago to about sixteen acres in the most recent years.[3] As regards the discrepancy which appears to arise in the case of vegetable crops, it may be said that criticism is not necessarily implied by bringing it forward for consideration. The " June *Return*," which is completed by farmers requires them to set out the areas under these crops. Areas of less than a quarter of an acre are added together and entered as " other crops." Many of the farms dealt with in this study have less than a quarter of an acre under any one market garden crop.

Some farmers, at least, do not appear to pay sufficient regard to horticultural crops when making up their *Returns*. The methods of collecting information which are in use do not provide for a full measure of these crops, and while this subject deserves more detailed consideration it may be said that the current *Statistics* tend to underestimate the production of these crops.

For purposes of analysis the farms under survey were divided into three groups :—

(1) Farms showing less than five market garden crops;
(2) Farms showing five and under ten such crops;
(3) Farms showing ten or more such crops.

But for this purpose, potatoes was not regarded as one of these crops. Potatoes were grown on all the farms, but in some cases only for home consumption. Where early potatoes were grown, these could properly be regarded as market garden crops, but as growing small areas of main crop potatoes for sale would be a feature of many other farms in this area, this type of production is not necessarily related to market gardening.

Production is almost entirely seasonal, and has been directed to meet the demand of a holiday centre, as may be seen from the list of crops. Excluding very small areas of culinary herbs, twenty-one crops were found on fifty-six farms.

Peas and carrots are the two most important crops. In general the farmers have interested themselves in the production of only a small number of the more common varieties of vegetables. Farmers producing the smaller number of crops (Group of *Under Five*) mainly confined their activities to peas, carrots and spring cabbage. But they had in all nine different crops.

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[3] *Agricultural Statistics*, Part I. Annual.

The seventeen farmers in Group 2 (*five to nine crops*) had eighteen different crops; while the eight farmers in Group 3 (*ten or more crops each*) grew twenty-one different crops.

As plots under different crops tended to be quite small, and crops were intermixed, it was found more convenient to measure

Market Garden Crops Grown.

Crop.	*Number of Farms on which crops were growing.*	*Area.*
Peas	51	11.95 acres.
Carrots	45	6.17 ,,
Spring Cabbage	30	3.15 ,,
Kidney Beans	20	0.75 ,,
Beet Root	18	0.73 ,,
Parsnips	17	1.30 ,,
Sprouts	15	2.87 ,,
Broad Beans	11	0.21 ,,
Lettuce	10	1,541 lin. yds.
Savoys	10	0.77 acres.
Cauliflowers	8	0.43 ,,
Spring Broccoli	7	3.15 ,,
Winter Cabbage	4	0.47 ,,
Onions	4	673 lin. yds.
Turnips	3	0.05 acres.
French Beans	3	0.02 ,,
Summer Cabbage	1	0.10 ,,
Rhubarb	2	210 lin. yds.
Spinach	2	722 ,, ,,
Spinach Beet	1	60 ,, ,,
Red Cabbage	1	10 ,, ,,

areas by linear yards of crops. In the case of peas and kidney beans for which wide rows and " sticking " is still common no other measure is possible. The statement of linear yards has been converted to superficial area in certain cases, but in others has been left as the final measure.

The crops have been separated into four main divisions: (*a*) Brassicae, (*b*) Peas, beans, etc., (*c*) Roots, (*d*) Miscellaneous.

In the Brassicae group the average area for each crop, ex-

Estimated Acreage of Cabbage and Other Crops.

Variety.	*Estimated Total Area.*	*Number of Growers.*		
		Group 1.	*Group 2.*	*Group 3.*
	Acres.			
Spring cabbage	3.15	12	11	7
Summer cabbage	0.10	—	1	—
Winter cabbage	0.47	—	3	1
Cauliflowers	0.43	—	8	2
Broccoli	3.15	2	2	8
Sprouts	2.87	1	7	7
Savoys	0.77	—	7	3
Mixed	2.81	—	1	3
Acreage grown	13.75	4.26	5.28	4.26

cept spring broccoli, is under a quarter of an acre for each farm on which it is grown. The average area of spring broccoli was nearer half an acre, but in this case one farmer had nearly three acres.

The farmers in Group (1) produced only three of these crops; those in Group (2) produced all; while those in Group (3) produced all except summer cabbage of which the area is very small.

Many of these farmers, while making no attempt to produce a regular supply of these products often extend their production to a larger number. Most of the farmers in the third group are interested in the production of regular supplies in order to maintain their connections with shops and consumers, and since the total land occupied is much smaller they have only a limited space available for any one crop or group of crops.

Amongst the peas and beans, peas are of prime importance, both as regards number of producing farms and area.

Estimated Acreage of Peas, Beans, etc.

Variety.	*Estimated Area.*	*Number of Growers.*		
		Group 1.	*Group 2.*	*Group 3.*
	Acres.			
Peas ..	11.95	26	17	8
Kidney beans .	0.75	4	10	6
Broad beans . .	0.21	1	5	5
French beans ...	0.02	—	1	3
Acreage grown ..	12.93	5.22	5.32	2.39

Only one farmer grew more than an acre of peas. The impression given is that many of the farmers wish to have small quantities of peas or beans on offer, but that very few are trying to produce on such a scale as would enable them to produce economically or to offer a large or attractive supply.

It was stated that too many peas were being produced and as a consequence prices were too low. Some difficulty in finding buyers was experienced during this last summer, but this was due to the drought. A number of farmers aimed at producing peas for sale towards the end of July and during August. Others made more numerous sowings in order that their total supplies might be spread over a longer period. The drought, however, reduced the normal growing period and farmers found that the peas sown for sale in August had to be marketed before the end of July. Thus the total local supplies of peas had to be marketed

within a shorter period and this was the real cause of the difficulties experienced.

Of the roots, carrots are the most important, accounting for approximately 75 per cent. of the total area under these crops.

Estimated Acreage under Roots.

Variety.	*Estimated Area.*	*Number of Growers.*		
		Group 1.	*Group 2.*	*Group 3.*
	Acres.			
Carrots	6.17	21	17	7
Parsnips	1.30	3	6	8
Beet root	0.73	2	9	7
Turnips	0.05	—	1	3
Acreage grown . .	8.25	2.93	3.02	2.30

Forty-five farmers were growing carrots, thus the average area per farmer was under one-sixth of an acre. In the case of the other three crops the average per producing farmer was considerably smaller. The area under beetroot and turnips is surprisingly small, although eighteen farmers produce the former.

Very little attention has been paid to the production of the more specialised crops, and Aberystwyth is dependent upon English border counties for its supplies.

Estimated Area under Miscellaneous Crops.

Variety.	*Estimated Area.*	*Number of Growers.*		
		Group 1.	*Group 2.*	*Group 3.*
	Lin. Yds.			
Lettuce	4,541	1	4	5
Spinach	722	—	—	2
Onions . . .	673	—	1	3
Rhubarb	210	—	—	2
Spinach beet . . .	60	—	—	1
Red cabbage	10	—	—	1
Total Lin. Yards	6,216	40	3,305	2,871

It will be seen that only a small number of the farmers produce these crops; most of the growers are in Group 3 (*farmers producing ten or more market garden crops*), and three market gardeners were responsible for the greater part of them.

Only four of the farmers were not growing potatoes for sale.

A number of farmers allow neighbours to plant a few rows of potatoes on their land, but these have been omitted from this study. The information below relates only to a portion of the local supplies.

Estimated Acreage under Potatoes.

Varieties.	*Estimated Area.*	*Number of Growers.*		
		Group 1.	*Group 2.*	*Group 3.*
	Acres.			
Earlies	14.42	25	13	7
Second earlies	2.58	11	6	3
Maincrop	42.33	30	15	6
Estimated Total Acreage	59.33	34.96	15.36	9.01

Nine different varieties of early potatoes were grown, but only " Sharpes Express " was of any importance, accounting for over ten acres. The average area per producing farmer in each group showed little variation from the general figure of just over a quarter of an acre. Although twenty farmers were growing second earlies, the total area was small. " Eclipse " was the most popular variety, and although five others were grown their combined total area was only equal to that of the former. Most of the farmers regarded the " King Edward " variety as a second early and commenced lifting these when the earlies were finished.

Maincrop potatoes were being grown by fifty-one farmers. Of the thirteen varieties " King Edward," " Kerrs Pink," and " Red King " were the most important. The areas under these three crops were : 10.84 ; 8.55 ; and 5.54 acres respectively. A number of farmers had made no change in their seed for several years and many of these had either no knowledge of the variety or had mixed several varieties together. A total of over nine acres was therefore recorded as mixed and unknown varieties. It has to be noted that in many cases these suffered badly from virus diseases. The average acreage per producing farmer for the three groups was as follows : Group (1), 0.84 ; Group (2), 0.72 ; and Group (3), 1.07 acres.

All the farmers produced a little fruit, but forty-five had none for sale. Nine sold only a very small quantity which was surplus to their requirements. The other two regarded their fruit as the source of an appreciable part of their income. Both

these farmers had small plots of strawberries, a number of currant and gooseberries bushes, and also apple, plum, and pear trees. One was producing figs, grapes and peaches for sale. In general, however, the local supply of fruit is of very little importance and far below local requirements. The production of flowers for sale was almost negligible. The range of varieties was limited to that commonly found in cottage gardens, and of these sweet peas were the most important. Eleven farmers were selling some flowers, and although they all had sweet peas for sale the total was under 800 linear yards. It was found that two of the farmers were growing over ten varieties of flowers, including 9,500 bulbs. These supplies were spread over the greater part of the year.

Three farmers had small areas under glass, one having about 5,600 square feet. A large proportion of this area was used for producing peaches, figs, grapes and roses. He had about 400 tomato and cucumber plants. All the rest of the available space was used for producing flowers and plants for transplanting in the open. The other two farmers used the glasshouses for the production of plants for their own use or for sale.

Very few farmers produce *Brassicae* plants for sale, most of them selling only those which are surplus to their own requirements. The farmers sell their plants to neighbours who find their own supplies inadequate.

Small garden plots of mint, sage and thyme were being produced for sale by two farmers : these crops therefore are of no economic importance among the farmers in this district.

(2) Relation of Market Crops to General Farming.

With these conditions in mind, the relation of the special market crops to the general farming conditions may be considered in some detail. The farms visited had a larger percentage of the total land under the plough than those in the county as a whole. The percentage under permanent pasture and rotational grasses was also higher.

Percentage of Total Area (excluding water) under Arable, Permanent Pasture and Rough Grazing.

	Cardiganshire.	*Survey Farms.*
Arable	11.93	19.49
Permanent Pasture	46.21	63.92
Rough Grazing	41.86	16.59
	100.00	100.00

The reason for this difference may be due to the fact that the average altitude of the Survey farms was lower than for the

county as a whole. Further, these farms were selected because arable crops were being produced. The comparable figures for each of the three groups are as follows :

	Group 1.	*Group 2.*	*Group 3.*
Arable	18.86	19.43	23.50
Permanent Pasture ...	62.66	65.47	67.56
Rough Grazing	18.48	15.10	8.94
	100.00	100.00	100.00

These figures indicate that farmers producing the larger number of market garden crops were occupying the better class land, and this evidence is further supported by the fact that a large proportion of the farms in Group 3 were situated at lower altitudes. Fifteen of the farms in Group 1 were situated at an altitude of 500 feet or more, but those producing the greater number of crops occupied land situated along the valleys, the soils of which are more fertile and kindly.

Altitude of Farms.

Altitude.	*Number of Farms.*			
	Group 1.	*Group 2.*	*Group 3.*	*Total.*
Under 100 ft.	1	1	—	2
100 and under 200 ft.	2	—	2	4
200 ,, ,, 300 ft.	4	4	3	11
300 ,, ,, 400 ft.	6	2	—	8
400 ,, ,, 500 ft.	3	5	1	9
500 ft. and over	15	5	2	22
Total	31	17	8	56

Aspect may be an important factor in market gardening and the following is a summary of the general position of the farms visited :

No. of Farms.	*Aspect.*
26	Southern or partially Southern.
17	Northern or partially Northern.
9	Western.
3	Eastern.
1	In a Valley.

The majority of the farmers were therefore producing their crops on land which possessed some degree of shelter from the cold east winds.

The farms surveyed showed a range of size between three

and 189 acres, but the majority lay within the range of twenty and 100 acres.

Size of Farms.

Size.	*Number of Farms.*			
	Group 1.	*Group 2.*	*Group 3.*	*Total.*
Under 20 Acres	1	3	4	8
20 & under 50 acres	10	4	—	14
50 ,, ,, 100 acres	12	5	4	21
100 ,, ,, 150 acres	4	4	—	8
150 Acres and over	4	1	—	5
Total	31	17	8	56

Only four farms were under ten acres in size and each of these was producing more than five crops. Occupiers of the smaller farms have felt the effects of the economic depression more accutely and have therefore made greater efforts to produce vegetables for local sale. Further, they are able to give more personal attention to the cultivation of these crops.

The production of market garden crops is not related to any one particular system of farming. Of the general systems practised store stock and mixed farming were the most important. In general the farmers derived the major parts of their incomes either from livestock or their products, the only exceptions being the three market gardeners.

Types of Farming.

General Description.	*Number of Farms.*			
	Group 1.	*Group 2.*	*Group 3.*	*Total.*
Producer-Retailer (Milk)	4	2	1	7
Store stock ..	13	6	2	21
Mixed	13	9	2	24
Sheep	1	—	—	1
Market gardening	—	—	3	8
Total ...	31	17	8	56

A greater number of market garden crops are produced on the mixed farms. These farms have a higher percentage of arable land and farmers have less difficulty in introducing

vegetable crops. There are only seven dairy farmers in the sample and most of these were producing a small number of crops. Milk producers generally have not used their contact with the consumer as a means of extending this side of their farming enterprise.

Some reasons may be suggested for the lack of interest in the production of market garden crops. A change in the system of farming, resulting in an increase in the area under arable and especially under specialised crops, would make an important increase in the demands for manual labour. The farms are mainly of a "family" character and the farmers may be reluctant to make any change which would compel them to employ hired labour. Some of the farmers, as for example those retailing their milk, are unable to give personal attention to the production of vegetables. Other farmers who do have more available time are not acquainted with the cultivation of the more specialised market garden crops. Thus farmers have confined their activities to the production of crops :—

(*a*) the cultivation of which does not differ greatly from the more common farm crops;
(*b*) which fit best into the existing farming system, and
(*c*) which do not demand any increase in manual labour.

Most of the produce is brought into Aberystwyth by pony and trap, but some growers send it by bus while others bring it in by car. The quantities are very small, thus transit cost in man and horse time is high.

(3) Marketing.

Methods of marketing vary considerably, some farmers sell the whole of their produce direct to the consumers, others sell all to the shops, while several follow no definite single practice. The following is a broad summary of the methods of disposal :

	No. of Farmers.
Retailing market garden produce only	4
Retailing with milk, butter and poultry produce	11
Selling to shops	31
Selling to shops and retailing	6
Selling to hotels and restaurants	3
Selling wholesale	1

Six of the milk retailers sell their market garden produce direct to consumers while one sells to a wholesale merchant. A much larger proportion of the store stock farmers than those with the mixed farming systems retail their produce. Many of the mixed farmers have grown vegetables for a number of

years and have established connections with the greengrocers in Aberystwyth. Several store stock farmers, however, have only recently commenced to grow these crops and have not established such good contacts with the shops. Supplies from these farmers are often less reliable than those from farmers who have had more experience.

Of the thirty-one farmers selling to shops, sixteen stated that they supplied shops when they received orders. The remainder had less difficulty in getting orders and of these twelve were in mixed farming. Those who found difficulty in getting orders had, in general, nothing but peas and potatoes to offer, while the others had a more varied supply of vegetables. The general practice of those selling to the greengrocers is to collect orders on Monday and in some cases on Thursday and Friday. If orders are obtained produce is delivered on Tuesday, Friday, or Saturday. Those selling direct to the consumers retail their produce on Mondays, a few also retail on Friday or Saturday. The milk sellers often carry some vegetables every day and the two market gardeners retailed three days each week during the summer. The following is a summary of the information relating to the number of deliveries per week into Aberystwyth.

Number of Deliveries per Week.

Method of Disposal.	*1*	*2*	*3*	*Daily.*	*When ordered.*
Retailing	4	1	1	6	---
Selling to Green-grocers	5	9	1		16
Selling to Green-grocers & retailing	1	5	---	---	--
Selling to Hotels and Restaurants	--	3	---	.	--
Selling to Wholesaler	--	---	—	---	1
Total	10	21	2	6	17

Those farmers who had established good contacts with the greengrocers or with consumers were the less critical of prevailing prices. Even when prices were low they were usually able to dispose of the whole of their produce. Some farmers have brought produce into Aberystwyth when they have not received orders, and if they have been unable to sell the produce it has been left with a greengrocer with instructions to get as much as he can for it. These growers found the greatest difficulty in

selling their peas which they were reluctant to take home again. Several stated that, in past years, they grew peas because these helped to sell their potatoes. The greengrocer had to take a quantity of potatoes or the farmer refused to deliver peas. But at the present time there is less dependence upon local farmers for peas. The growers complain that greengrocers buy produce grown outside the area even when local supplies are available. The explanation given for the greengrocers' preference for outside supplies is, firstly, that quality is better, and secondly, there is a greater variety of supplies.

(4) Local Production and Demand.

Although the local market is small the local supplies of market garden produce are very inadequate. The population of Aberystwyth, like that of all seaside resorts, is variable so that it is difficult to estimate accurately the total demand for these crops. Nevertheless it is safe to say that at present, the existing supplies of any one crop are insufficient to meet the requirements of the resident population. In a normal year it is certain that a considerably larger area of peas could be grown with advantage, and the areas under many of the other crops would have to be increased enormously in order to supply all the local demand.

At the present time farmers are producing market garden crops on a scale too small to be economical. The claim that "local farmers cannot produce peas economically unless they obtain three pence per lb." can only mean that this is the case under the current local methods of production. If local farmers are to compete successfully with more distant producers they must be prepared to adopt modern methods of production and marketing. They must consider quantity for cheap production, quality for high price, and regularity of supplies during the season for maintaining connection with shops.

While the natural conditions are not as favourable as those of the English counties still the evidence shows that these crops can be grown economically. There exists plenty of good land situated along the valleys where the area under these crops could be increased. Individual farmers have shown that with care and attention good quality vegetables and salad crops can be produced. The range of crops can be widened so that fairly continuous supplies can be offered for sale. At the present time Aberystwyth has a fair supply of local produce during the three summer months but for the other nine months is dependent upon outside growers. By increasing the area under broccoli, savoys,

sprouts, summer and autumn cauliflowers, the local supplies could be made more continuous.

The contact between the greengrocers and general wholesalers of English and imported produce is constant and intimate. The wholesalers have a good knowledge of local requirements and can offer a great variety of produce. English producers show greater discrimination in the selection of produce for the market and have therefore gained the confidence of both the greengrocer and consumer, while Foreign or Dominion produce is generally carefully selected and presented.

Uniformity in the methods of marketing is as important as quality, variety and continuity of supplies. If all the local grown produce were sold through the shops improvement in quality would be less difficult to obtain. Greengrocers make their produce look attractive in order to secure custom. "Shop prices" tend to be more uniform and there is little tendency to cut prices in order to get buyers. Much of the produce which is sold at the door would not sell in the shops and often it is only through very low prices that farmers are able to sell at the door since most people prefer to buy at the shop. So long as these practices exist no uniformity in prices or quality can be secured and maintained. The establishment of some form of central market would do much to eliminate the present costly and uncertain methods and conditions of marketing. It would not injure the relationship between the good producer and the retailer but would tend to strengthen his position by educating the other farmers in the better methods of selecting and preparing produce for market. The bargaining position of the farmer would be strengthened. The retailers would have a better knowledge of available local supplies and would be placed in a better position to compare the various qualities of produce offered in the market.

From the general and statistical information obtained by the survey some suggestions may be made. With regard to potatoes, it may be said that growers should change their seed more frequently because this would have a significant influence on yields. Mixing of varities should always be avoided because they vary in cooking requirements and qualities. It is quite possible that seed of suitable varieties for local production, free of virus diseases, could be produced in the higher or more exposed parts of Cardiganshire, as in parts of North Wales. In any case better selection of varieties, more frequent changes of seed, and separation of varities of potatoes are necessary and

would give better results in production. As regards fruits, strawberries are being grown successfully in local gardens, and though the local market is a limited one there is no reason why farmers of the district should not develop a local supply to meet requirements. This is one of the fruits which suffer by time and transport, and of which local supplies may expect to obtain a preference by reason of freshness and general quality appearance. Shopkeepers will not purchase freely local supplies of cooking apples because they are not graded. Generally, there appear to be opportunities of increased production by such modern methods as would provide an attractive supply. Local supplies of dessert apples could be increased considerably. The lack of supplies appears to be mainly due to an old belief that dessert fruit cannot be grown successfully in the district, but some trials of varieties would show possibilities of local production. Generally, Aberystwyth appears to be a town in which demand for fruits and salads is comparatively small and prices high, but it is difficult to assess the relations between these two conditions. It is known, however, that the potential demand for salads sometimes fails to become effective because of the lack or the poor qualities of supplies, or of comparatively high prices for rather low quality of goods offered. It appears that local growers and shopkeepers, acting in concert, could create both supply and demand for dessert fruits and salad crops to their mutual advantage.

PRICES OF FARM PRODUCTS.
WHOLESALE-RETAIL MARGINS.

By W. H. Jones, M.Sc.,

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During the last few decades the prices of most farm products have fluctuated to an appreciable extent. This phenomenon has become more apparent in recent years and has at times been so severe as to affect detrimentally the interests of many people engaged in the production of food. The factors responsible for such price movements have been frequently enumerated but only few attempts have been made to determine the extent to which each of the major factors affect prices. It is generally claimed that a rise or fall in the price of a commodity affects the quantity produced at a subsequent date but

little is known as to the length of the period that must lapse before the effect is felt; and even the occurrence of the effect is not certain as unforeseen causes may come into play during this interval and exert some contrary influence, so the anticipated response to the price change may not occur.

Demand is one of those forces which operates to raise or to depress the price level, but again little is known of the precise relationship between changes in demand and in price. It is the retail price of a commodity, however, that is in contact with demand whereas, in the majority of cases, supply is in contact with the wholesale price. Some continuity throughout the whole series of supply and price relationships is to be expected. Significant changes in wholesale prices should normally be followed by changes in retail prices and unless this is the case the price mechanism will fail to guide the forces of production and consumption in the way anticipated.

Fluctuations in wholesale prices sufficient to exercise influences on supply leading to an increase or decrease are not always accompanied by equivalent changes in retail prices, and under these circumstances demand and supply are subject to somewhat different influences or to different degrees of the same influence.

During the last few years the spread between wholesale and retail prices has, in some cases, been increasing; as a result, some of the changes that occur in demand may have but little ultimate effect on wholesale prices. Production in general is guided by the movements of wholesale prices, but unless both sets of prices move more or less together there will be disequilibrium between the supply of a commodity and the demand for it.

The problem of discovering the true relationships between the factors determining the price of any one commodity is complicated by the effects that the price of competing commodities may have upon the situation. The effect may be exerted in two ways: demand for the lower priced commodity would probably increase, whilst a less than proportionate decrease in the demand for the higher priced article would occur. On the other hand, some producers would be in a position to modify their systems in accordance with the change in relative prices, and would gradually tend to produce more of the higher priced commodity.

Of course it is not always the quoted wholesale price that

a producer receives for his commodity. Many farmers dispose of their supplies in the retail market and in consequence obtain the prices comparable to those paid by consumers. But the difference in the prices received by groups of producers can in general be accounted for in terms of the different services offered with the articles, and on the whole it can be said, that it is the wholesale price that producers receive and that this is the price that directly affects production, in so far as prices exert influences upon supplies.

The comparatively low incomes made by farmers in recent years have been ascribed in part to the persistent fall of wholesale prices. On the other hand, it is said that retail prices have not declined to the same extent, and that this failure of response has hindered expansion of consumption. With the rapid developments in the applied sciences and arts of production during the last few decades the production of most commodities has increased and much greater supplies of foodstuffs have become available. One result is the occurrence of disequilibrium between the effective demand for and the supply of many farm products. It is of interest therefore to investigate the price structure with a view to finding some explanation of this situation.

The quantity and the quality of distributive services have changed in recent years, consumers have been demanding more services, more frequent or regular attendance, whilst commodities are better handled, more expensively packed, and often dealt with in smaller lots than was formerly the case. The increased cost of distributive services as a result of such changes need not adversely affect the prices received by farmers. If the total supply of the commodities affected was unchanged and demand continued at its previous level the additional cost involved in handling the goods would in general be passed on to the consumers. If, however, the charges made by the middlemen for the same distributive services were unjustifiably enhanced wholesale prices would probably tend to fall as it would be more difficult to pass the increase on to the consumers. Under these conditions producers would be likely to suffer unduly depressed prices.

In the same way as there has been an improvement in productive efficiency ample opportunities have been available for increase in the efficiency of distributive services. A general improvement throughout the processes of production and distribution should tend to raise the return to the farmer rather

than lower it, yet on the whole producers in recent years seem to have borne a disproportionate share of the increasing cost of distributive services.

Taking a few farm products which are of especial importance in Welsh agriculture, it is found that during the post-war period there has been such a phenomenal drop in wholesale prices and in the value of the output of farms that the agricultural industry has been seriously disturbed. A comparison of two relevant series of index numbers indicates that retail prices have been maintained at a higher level than wholesale prices.

TABLE I.

Year.	*Board of Trade Wholesale Prices.*	*Cost of Living.*	*Index of Retail Prices. All Food.*	*Index Number. of Prices. (Wholesale) Agric. Produce*
	1913 = 100.	*July, 1914 = 100.*	*1914 = 100.*	*1911-13 = 100.*
1920	307	249	256	292
1921	197	226	229	219
1922	158	183	176	169
1923	159	174	169	157
1924	166	175	170	161
1925	159	176	171	159
1926	148	172	164	151
1927	142	167.5	160	144
1928	140	166	157	147
1929	136	164	154	144
1930	119	158	145	134
1931	104	147.5	131	120
1932	102	144	126	112

It is true that wages are an important factor in distributive costs and that wages did not fall as rapidly as prices during this period. In consequence it was to be expected that retail prices would remain at a comparatively high level during the period of general deflation. Again, the growth of city populations and the demand by consumers for more services with each article of food have caused some justifiable increases in middlemens' margins. Also, supplies are now transported over greater distances and often at more regular intervals than was formerly the case.

Considerable developments have been made in agricultural production—the increasing use of machinery, the rising yields of crops and the heavier production of many classes of animals as, *e.g.*, dairy cows, have tended to reduce the cost of production per unit of product. The results of such improvements should in part accrue to farmers and in part to consumers after

necessary allowances have been made for the increased distributive costs. Costs of increased services should rightly be paid by the consumers and should raise retail prices without depressing wholesale markets. If, however, the costs of increased services are too high, or if additional charges are made for the maintenance of wages or profits at levels too high in relation to the general circumstances, without an extra service being rendered, at least part of the effects would undoubtedly be passed backwards, and would reduce the farmers' revenue.

If retail prices had moved consistently with wholesale prices, allowing for the increased cost of distributive services, it could not be inferred that the small returns obtained by farmers are the result of increased middlemens' margins. Again if the retail prices of foodstuffs had been reduced concurrently with the fall in the general price level, it could not be maintained that demand had been restricted from this cause.

In the absence of an adequate explanation of the comparatively unfavourable returns obtained by farmers during recent years arising from a study of the margins between wholesale and retail prices the fault may be found to rest in part with the producers themselves. Either they did not attempt to reduce costs of production concurrently with the declining wholesale price level or they produced supplies in excess of effective demand or did not successfully meet changes in customers' requirements. Farmers in this country can modify their systems and practices of production if they so desire to meet changes in market conditions. But it is not possible for drastic changes to be made immediately; lags are of varying length according to the conditions of the various enterprises.

It is rather difficult to isolate changes in the price of any particular commodity as a result of variations in its supply because allowances must be made for several other factors which influence the final result. One way of surmounting this difficulty is by indicating the purchasing power of each commodity; this gives the comparative amount of other commodities for which a unit quantity of the article could be exchanged. Ultimately farmers are more interested in relative values of their commodities rather than in the prices which they command.

Milk.

It is apparent that the retail price of milk has remained at a comparatively high level in recent years and the margin between its retail and wholesale price has shown a tendency to

widen. The general agricultural price level has shown a far more severe fall than the price of milk. The purchasing power of milk, on the other hand, has shown a definite and persistent rise throughout. The quantity of milk produced has also shown a steady upward trend. One of the problems of real importance to those in the business is this: Is the increase in middlemens' charges justified? If not, it would undoubtedly curtail demand and would detrimentally affect producers; on the other hand, if the increased charges are balanced by the cost of additional services they are a legitimate levy and should be borne by consumers. Middlemen, it is true, have had to pay higher rents, wages, etc., in the post-war period, but this increased cost can be allowed for by deflating the margin between the retail and wholesale price in each year. A modified form of Carl Snyder's method of calculating an index of the general price level[1] has been used for the purpose.

This index number is arrived at by combining four index numbers, with weights in the proportions stated.

	Weight.
Board of Trade: Wholesale prices	2
Bowley's: Wage	3½
Ministry of Labour: Cost of Living	3½
Ministry of Labour: Rent	½

The index obtained by this method takes into consideration changes in both the prices of a number of commodities and in the cost of services. The index is based on prices in 1913, but as prices were higher during the years under review than they

TABLE II.

Milk Margins.

Year.	1 Wholesale. Price.	2 Retail Price.	3 Index of Prices and Services.	4 Margin.	5 Deflated Margin.	4-5 Difference.
	s. d.	s. d.		*Pence per Gallon.*		
1924	1 2⅞	2 1	172	10⅛	9	1⅛
1925	1 2⅞	2 1	172	10⅛	9	1⅛
1926	1 2⅞	2 0	169	9⅛	8⅞	0¼
1927	1 2	2 0	166	10	8¾	1¼
1928	1 2⅛	2 0	164	9⅞	8⅝	1¼
1929	1 2¾	2 1	163	10¼	8½	1¾
1930	1 2⅛	2 1	157	10⅞	8¼	2⅝
1931	1 0⅞	2 0	149	11⅛	7⅞	3¼
1932	1 0⅝	2 1	146	11⅜	7⅝	3¾
Average	1 2⅛	2 0⅝	162	10¼	8½	1¾

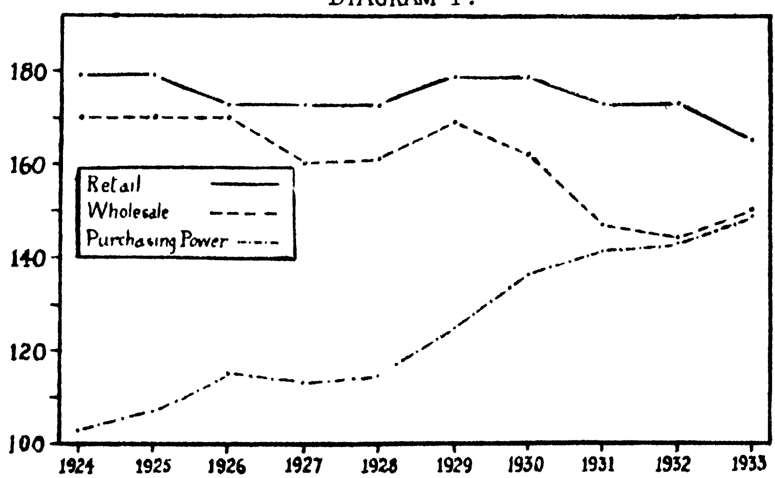
[1] See "Business Cycles." Carl Snyder.

were in that year it indicates the actual position in any year compared with the basal year. For the purposes of this study therefore the index indicates the necessary rise in the charge of providing the same distributive service as in the pre-war year. A margin over and above this can be considered as a payment for additional services or possibly in part as an excessive levy.

In the case of milk it is clear that there has been a tendency for the magin to widen in recent years; but on the other hand, a proportion of this increase is permissible owing to the enhanced costs of retailing. Compared with pre-war years, therefore, no objection can be taken to a certain increase of middlemens' margins. The permissible increase over 1914 has, of course, tended to fall since 1924 whereas the actual margin widened over this period. The figures in the last column of the table indicate, therefore, the charges that middlemen have levied on consumers to cover the increased services they have given with the milk, the adequacy or otherwise of these sums cannot be finally settled as there is no measure of the increased services performed. If the margin in recent years has been too wide, the consumption of milk has been retarded and it is the producers who have borne the charge as they have been obliged

Milk: Price Indices 1924-1933.

DIAGRAM I.



to take a smaller proportion of the sum paid by consumers than would otherwise have been the case. It is true, however, that the wholesale price of milk has been relatively high and that its purchasing power has shown a steady rise throughout the

period, but nevertheless, supplies became somewhat short in 1931-2 and prices were immediately advanced. Although retailers have had to meet higher costs in the post-war decade the same can be said of producers. A comparatively favourable wholesale price level for milk during the period does not of itself indicate high profits in the industry. Much pressure has been brought upon milk producers to modernise their businesses and this has meant higher costs of production. Efficiency in management should, of course, keep costs at a relatively low figure in both the producing and the retailing aspects of the trade. It seems therefore difficult to justify a state of affairs where 45 per cent. of the final price paid by consumers is absorbed in traders' margins as against 37 per cent. in pre-war days.

Graph 1 indicates the movements of both wholesale and retail milk prices compared with pre-war; had both sets of prices changed to the same degree in later years, the widening gap, shown in the graph, would not have occurred. With the exception of the last three years of the period, however, the margin has compared very favourably with that which prevailed in 1914. It was after 1930 that the actual margin diverged perceptibly from that which appeared to be justified.

Beef.

It is impossible to discuss the economics of agricultural production with a view to elucidating the factors responsible for changes in the price of one commodity unless the forces governing the prices of others, which farmers are in a position to produce, are treated simultaneously. If, for example, the market for one product has improved farmers may not be attracted to it if that of another has improved more than proportionately. It is apparent that prices of fat cattle in recent years have been low : Table III, however, shows that the gap between the price of fat cattle and the wholesale price of beef has remained fairly steady. In so far as wholesalers of meat have been obliged to meet increased costs in the form of higher wages and rents since 1913 they have been justified in maintaining a wider margin between the prices they paid and those they charged.

There are in fact several stages between the sale of a beast by a producer and the final disposal of the meat to the consumer and there are several margins but any undue inflation of one of them would inevitably affect the price somewhere along the

series of transactions. In the case of beef two margins are dealt with, *viz.* (*a*) that between producer and wholesaler and (*b*) wholesaler and retailer.

TABLE III.

Producer-Wholesaler Margin.

Year.	*Margin.*	*Deflated Margin.*	*Difference.*
	Pence per lb.	*Pence per lb.*	*Pence per lb.*
1924	3	3½	— ½
1925	3¼	3½	— ¼
1926	2	3	— 1
1927	2	3	— 1
1928	2¾	3¼	— ½
1929	2¾	3¼	— ½
1930	3	3	—
1931	2¾	3	— ¼
1932	3	3	—
Average ...	2¾	3¼	— ½

Producer: " Shornhorn, Hereford, Devon. Second quality Live Weight."
Wholesaler: " English Beef, Longsides. Second quality."

It is seen from the table that in most years wholesalers could justifiably demand just over 3d. per lb. for the same services as they rendered in pre-war days. The margin in each year was, of course, wider than in 1914 but not as wide as would be expected in consequence of the rise in costs. When the deflated figures are subtracted from the actual, minus values are obtained: therefore except in 1930 and 1932, the two sets of prices were in reality nearer to one another than formerly. This may, of course, be the result of a rise in efficiency in the handling of supplies during recent years and in consequence a reduction in costs of marketing. The development of large central markets and abattoirs, together with the use of more economic methods, may eventually result in a considerable decline in costs per unit of product but as yet such developments have not occurred to an appreciable extent. Nevertheless it is encouraging to find that the gap between farm and wholesale prices has not expanded unduly in recent years. Far too little attention is given in this country to the utilisation of by-products at our abattoirs. It is claimed that in some American abattoirs where great attention has been paid to this part of the problem farmers often receive nearly the full market value of the dressed animal as the utilisation of by-products has been so profitable that the charges for selling, killing and dressing are covered by the

income from the sale of by-products. Undoubtedly there is much room for improvement along these lines in this country as the gap between what farmers receive and the price to the consumer could probably be reduced by further developments of centralised slaughter.

The price received by the producer, however, must ultimately be dependent upon that paid by the consumer. The retailers' margin therefore must be considered an important factor in the situation. The work of retailing is largely a personal service, consequently wages form a high proportion of total costs. The table below indicates, however, that while the actual cash margin has in general been declining in recent years, it has remained throughout above that necessary to cover the same work as was performed in the pre-war year. In fact the actual margin has been higher on the average by nearly 2d. a lb. than was required on the estimate of costs of maintenance of previous service.

TABLE IV.

Wholesale-Retail Margin.

Year.	*Margin.*	*Deflated Margin.*	*Difference.*
	Pence per lb.	*Pence per lb.*	*Pence per lb.*
1924	8⅝	7⅛	+ 1½
1925	9	7⅛	+ 1⅞
1926	9¼	7	+ 2¼
1927	9¼	6⅞	+ 2⅜
1928	8¾	6¾	+ 2
1929	8⅞	6¾	+ 2⅛
1930	8⅜	6½	+ 1⅞
1931	8⅜	6⅛	+ 2¼
1932	7⅝	6	+ 1⅝
Average	8⅞	6⅞	+ 2

Retail: "Ribs of Beef."

The distribution of food is not organised into large units; on the contrary there are many small and scattered shops; there is much overlapping and in general overhead charges in the business are high. Retail prices should be adjusted to meet changes in wholesale prices in much the same way as the latter fluctuate with variations in the supply of beef cattle. This is in fact the only way to move heavy supplies into consumption. Most classes of consumers will take more of a commodity if the retail price declines but the lowering of retail prices in consequence of downward movements in wholesale prices is becoming more

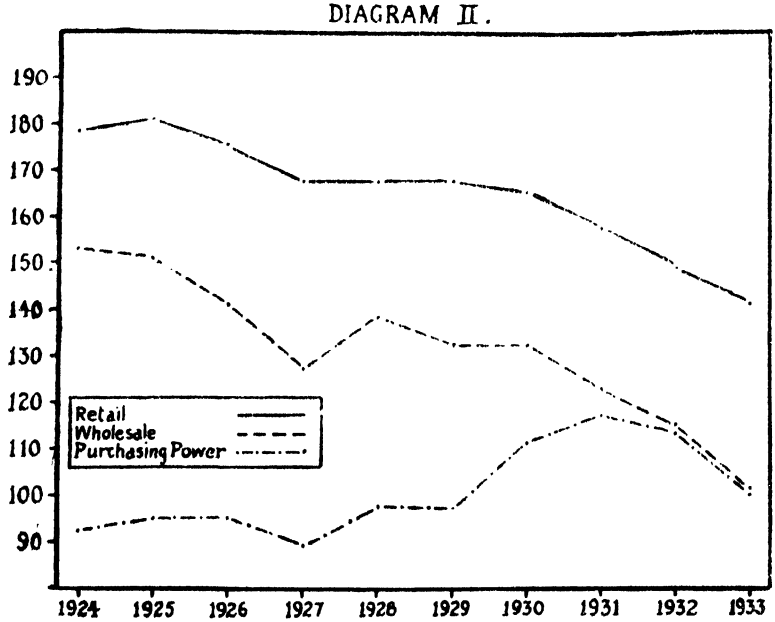
difficult as many retailers are now called upon to perform certain duties, such as keeping meat in edible condition, that were formerly done in the home, and the cost of providing such services does not decline with a fall in the wholesale prices of the product handled.

Efforts are constantly being made to discover new mechanical processes in the preparation of food and new or more effective methods of distribution which include the provision of additional services for the convenience of the housewife. Among the technical improvements of recent years has been that of refrigeration for perishable products and the necessity of keeping them at a constant temperature during transit and storage will certainly lead to higher costs of distribution but if the products can reach consumers in a more desirable form, or with less physical wastage than was formerly the case the movement need not affect producers detrimentally even though the retail price is advanced.

The enhanced margins between retail and wholesale prices of beef in recent years have probably been occasioned by increased

Beef: Price Indices 1924-1933.

DIAGRAM II.



costs, but the cost per unit of product handled could certainly be kept lower than it is at present by an improvement in the efficiency of distribution. The economy of centralised slaughter

has been patent in other countries but this advantage may be lost by inefficiency in other necessary stages in the distributive organisation.

Although both the retail and the wholesale price declined appreciably towards the end of the period under review, the former remained on the average at a comparatively high level. Between 1927 and 1930 was a period of relative stability, the retail price of beef stood between 65 per cent. and 70 per cent. above the pre-war figure, whereas the price of fat cattle was only about 35 per cent above the basal period. In later years a rather sharp decline set in, but the prices received by the producers suffered the more severe decline as in 1933 they approached the pre-war level.

Mutton.

In the case of mutton the actual cash margin has varied between 7⅛d. and 9½d. a lb. around an average of 8½d. In the pre-war period the margin stood at about 4d. a lb.; it is seen, therefore, that during the period under review the margin has remained on the average about twice as high as was the case formerly. When an allowance is made for changes in general prices of materials and services as is done in the calculation of the deflated margin, the gap still appears to be comparatively wide.

TABLE V.

Wholesale-Retail Margin.

Year.	*Margin.*	*Deflated Margin.*	*Difference.*
	Pence per lb.	*Pence per lb.*	*Pence per lb.*
1924	7⅞	6½	+ 1⅜
1925	8⅜	6½	+ 1⅞
1926	9⅜	6⅜	+ 3
1927	9½	6¼	+ 3¼
1928	8¼	6⅛	+ 2⅛
1929 ...	8	6⅛	+ 1⅞
1930	7⅛	5⅞	+ 1¼
1931	7⅞	5½	+ 2⅜
1932 ...	8⅞	5½	+ 3⅜
Average	8½	6	+ 2½

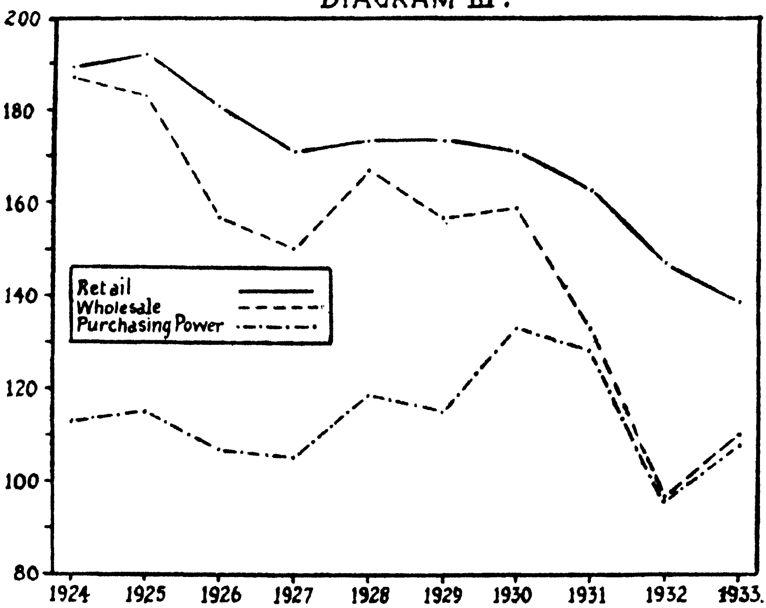
Retail: " Legs of Mutton."
Wholesale: " English Mutton, second quality."

The difference between the actual and the estimated permissible margin on fixed services has varied between 1¼d. and 3¼d. a lb. with an average of 2½d. per lb. The retail price of mutton shows two rather significant falls, the first between 1925

and 1927 and the second after 1930. These downward movements coincided with changes in the prices received by producers but the fall of the latter was considerably more severe. The failure of the retail price to move in appreciably the same proportion as the wholesale price undoubtedly hindered the movement of the commodity into consumption and demand was to some extent restricted. The effect of a decline in the wholesale price was only very faintly perceptible to the consumers; they were not encouraged to increase their purchases as retail prices were maintained at a comparatively high level.

Mutton: Price Indices 1924-1933.

DIAGRAM III.



Under such conditions farm prices become unduly depressed and an increase of supplies may result in a diminution of the producers' revenue if the price they receive falls more than in proportion to the increase of supplies. The prices and the purchasing power of fat sheep during 1931 and 1932 seem to indicate that producers were suffering from the unduly high retail price of mutton as, during these years, although a fall was occurring it did not proceed at a sufficiently rapid rate, and in consequence, the margin widened.

Butter.

The margin in the case of home produced butter has remained fairly steady, but it has been consistently above the

1914 figure. The methods of producing and marketing butter in this country have not undergone any considerable changes in recent decades. The bulk is still made on farms although butter factories are increasing in numbers. The price of British butter is governed to a large extent by the price of imports, this is not surprising in view of the fact that about 89 per cent. of the total consumed in the country comes from abroad.

TABLE VI.

Wholesale-Retail Margin.

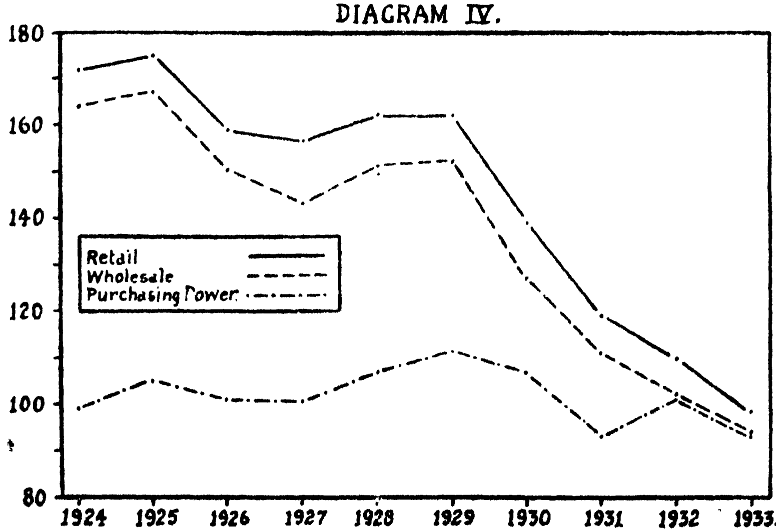
Year.	*Margin.*	*Deflated Margin.*	*Difference.*
	Pence per lb.	*Pence per lb.*	*Pence per lb.*
1924 ...	$2\frac{7}{8}$	$1\frac{3}{4}$	$+ 1\frac{1}{8}$
1925	3	$1\frac{3}{4}$	$+ 1\frac{1}{4}$
1926	$2\frac{3}{4}$	$1\frac{3}{4}$	+ 1
1927	$3\frac{1}{2}$	$1\frac{5}{8}$	$+ 1\frac{7}{8}$
1928 ...	3	$1\frac{5}{8}$	$+ 1\frac{3}{8}$
1929 ...	3	$1\frac{5}{8}$	$+ 1\frac{3}{8}$
1930	$3\frac{1}{4}$	$1\frac{3}{4}$	$+ 1\frac{1}{2}$
1931	$2\frac{1}{4}$	$1\frac{1}{2}$	$+ \frac{3}{4}$
1932	$2\frac{1}{4}$	$1\frac{1}{2}$	$+ \frac{3}{4}$
Average	$2\frac{7}{8}$	$1\frac{5}{8}$	$+ 1\frac{1}{4}$

Retail: "Fresh English."
Wholesale: "Average first and second quality, British."

A large proportion of the home produced article is sold direct by producers to retailers or consumers, wholesale transactions are of a rather limited character. Both the price and the purchasing

Butter: Price Indices 1924-1933.

DIAGRAM IV.



power of butter have been comparatively unfavourable during the period under review. Up till 1929 however the wholesale price although somewhat erratic remained about 50 per cent above the pre-war figure, in subsequent years, however, it showed a very serious decline. The retail price throughout the period has changed in sympathy with the wholesale price and the gap between them has not been as wide as in the case of some other products. Nevertheless when an appropriate allowance is made for the increase in middlemens' handling costs the margin appears unduly inflated.

Many farmers, however, are in a position to obtain the full retail price for their commodity especially if they dispose of it in country markets where a fairly large proportion is bought by consumers. Under such conditions the price received by the producer covers the cost of certain services as well as the article itself.

Unfortunately, however, a high percentage of the butter produced in this country does not compare very favourably in quality with the oversea supply. Much second quality butter is produced on farms where obsolete methods are still in vogue and until there is greater assurance, than at present exists, that home supplies are of fairly high quality, it is doubtful whether consumers will be prepared to pay higher prices than those ruling at present.

Eggs.

With regard to eggs the margin has fluctuated within comparatively wide limits, but this variation is to some extent to be

TABLE VII.

Wholesale-Retail Margin.

Year.	*Margin.* *Pence per doz.*	*Deflated Margin.* *Pence per doz.*	*Difference.* *Pence per doz.*
1924 ...	$3\frac{1}{8}$	$3\frac{7}{8}$	$-\ \frac{3}{4}$
1925	$2\frac{5}{8}$	$3\frac{7}{8}$	$-\ 1\frac{1}{4}$
1926	5	$4\frac{5}{8}$	$+\ \frac{3}{8}$
1927	$5\frac{7}{8}$	$3\frac{3}{4}$	$+\ 2\frac{1}{8}$
1928	$5\frac{5}{8}$	$3\frac{3}{4}$	$+\ 1\frac{7}{8}$
1929	4	$3\frac{3}{4}$	$+\ \frac{1}{4}$
1930	$4\frac{1}{4}$	$3\frac{3}{4}$	$+\ \frac{1}{2}$
1931	$4\frac{1}{4}$	$3\frac{3}{8}$	$+\ \frac{7}{8}$
1932	$5\frac{3}{8}$	$3\frac{3}{8}$	+ 2
Average ...	$4\frac{1}{2}$	$3\frac{3}{4}$	$+\ \frac{3}{4}$

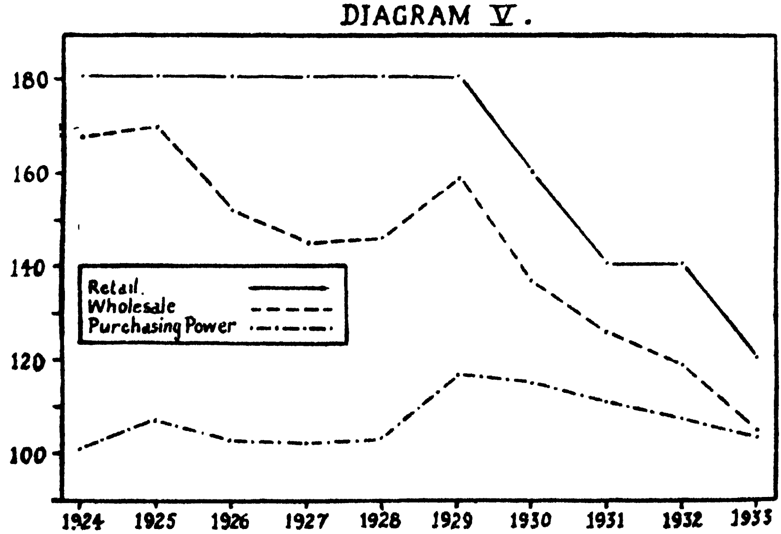
Retail: " Fresh Eggs."
Wholesale: " English Ordinary, average first and second quality."

expected. The wholesale price often varies considerably within relatively short periods partly in response to changes in the supply. Both the quantity produced and the wholesale price show a marked seasonal variation. The number of eggs offered for sale is generally at its maximum between March and May and at its minimum in November; prices on the other hand vary inversely, touching the lowest point in April.

The demand for eggs is fairly uniform, nevertheless there is an appreciable seasonal variation in consumption. The quantity of eggs imported is fairly steady throughout the year and consequently the incidence of oversea supplies does not seriously affect the movement of prices. The fluctuations therefore in the quantities of eggs offered for sale has a very disturbing effect upon wholesale prices. Between 1924 and 1929 retail prices remained fairly steady from year to year whereas wholesale prices were erratic. During 1927 and 1928 the margin was particularly wide as retail prices did not decline in sympathy with the fall of wholesale prices. When an estimated allowance is made for changes in costs of marketing it is seen the actual margin was, in most years, above that necessary to cover the same services as were performed in the pre-war years. An average of 4d. a dozen to cover collection from farm, candling, grading, packing and transport to consuming centres, appears to be high as this work is now being done by many egg packing stations in the country at a considerably lower figure.

Eggs: Price Indices 1924-1933.

DIAGRAM V.



It is claimed that traders are frequently prepared to pay a higher price for imported eggs of high quality than for nondescript supplies of British eggs. Many of the oversea consignments are subjected to inspection before dispatch to this country and where such conditions are imposed no inferior supplies are allowed to reach the British markets. One of the most important problems facing home producers is that of improving the quality of supplies in order that traders may have reasonable assurance that the eggs sold are of good quality. The present methods of marketing eggs are rather chaotic as the requirements of consumers are only imperfectly conveyed to producers. No real attempt is made to market the product either in the best way, in the right quantity, or at the most suitable time. The margin between the price paid by the consumer and that received by the producer is sufficiently wide to enable the work of marketing to be more efficiently performed.

At the present time attempts are being made to market some home produced foodstuffs in a more orderly way. These efforts may enable the work of marketing to be done at lower cost per unit of product handled than is the case at present. The work of assembling processing and distributing foodstuffs in this country needs to be improved in view of the developments in the marketing of oversea supplies. It has been shown that in general the margins between producer and consumer prices are now wider than was the case in pre-war days and that farm prices have in many cases reached low levels. An improvement in the methods of marketing in the future may enable production and consumption to be more effectively equated and this would be of considerable benefit to the agricultural industry.

A SMALL FARMER'S ACCOUNTS.

By C. Bryner Jones, C.B.E., M.Sc.,
Welsh Secretary to the Ministry of Agriculture.

Through the courtesy of a friend the writer had access recently to a book which contains a record of the receipts and payments of a small farmer in Merionethshire from 1897 to 1930. It is a simple form of book-keeping, showing only the cash transactions of the owner of the book for each year during that period. There is no indication of the value of the stock and of how the valuation varied from year to year, or any attempt to prepare a balance sheet, but while for this reason the records do not disclose the real financial

position of the farmer at the close of each year, as a more complete system of account-keeping would have done, they are nevertheless of great interest to those who are interested in the simpler economics of small scale farming. The farm to which the accounts relate is in a poor, cold district, is about six miles from a market and is fairly representative of a large class of small farms which are in many ways characteristic of the hill districts of the Principality, though they are now fewer in number than they were in the past. The actual area of which these holdings are comprised may often be considerable, but so much of the land often consists of rough and broken hill, or wet ground that the size of the holding in acreage gives little or no indication of its real economic character. This can only be judged by the head of stock the holding normally carries. The stock on the small farm with which we are now concerned consisted of three cows, with two or three calves as the case might be, about forty to fifty ewes and their lambs, a pony, two or three fattening pigs and some poultry. The rent was £20 per annum.

The total receipts and payments in cash as shown in the account-book were as follow :—

Year.	*Receipts.* £	s.	d.	*Payments.* £	s.	d.	*Surplus.* £	s.	d.
1897	44	8	0	23	9	6	20	18	6
1898	52	11	1	35	10	5	17	3	11
1899	56	16	1	44	9	3	12	7	1
1900	86	12	9	53	18	2	32	14	7
1901	68	9	8	42	13	3	25	16	5
1902	68	11	7½	33	2	0	35	9	7½
1903	77	8	8	50	12	3	26	16	5
1904	70	13	3	42	5	9	28	7	6
1905	66	10	0	39	7	11	27	2	1
1906	64	3	1	35	1	2	29	2	2
1907	92	19	3	38	8	7½	54	10	7½
1908	55	19	5	39	17	8	16	1	9
1909	65	15	9	40	16	4	24	19	5
1910	44	18	11	32	1	1	12	17	10
1911	41	15	8	34	6	2½	7	9	5½
1912	83	14	9	36	5	1	47	9	8
1913	68	2	10	33	10	7	34	12	3
1914	61	19	7	36	14	8	25	4	11
1915	50	11	10	37	9	7	13	2	3
1916	86	19	10	45	3	3	41	16	7
1917	109	0	4	40	1	0	68	19	4
1918	109	0	2	44	2	11	64	18	3
1919	96	19	3	49	5	6	47	13	9
1920	146	13	4	49	13	10	96	19	6
1921	74	0	2	58	1	9	15	18	5
1922	115	11	4	40	10	9	75	0	7
1923	107	19	8	43	19	4	64	0	4
1924	120	1	4	49	11	11	70	9	5
1925	87	19	8	47	9	0	40	10	8
1926	71	10	3	46	6	0	25	4	3
1927	78	19	5	35	0	9	43	18	8
1928	68	9	7	51	8	1	17	1	6
1929	101	0	4	55	13	7	45	6	9
1930	77	9	1	73	0	6	4	8	7

It will be observed that, as might be expected, the receipts varied very considerably and that the payments, while they varied too, were much more steady. There was clearly a determined effort on the part of the farmer to keep his expenditure within such limits as would enable him to show a certain surplus of cash on his transactions each year. In some years, especially after the War, the surplus amounted to what would undoubtedly be to him a substantial sum, the bulk of which he would put by. The criterion by which he would measure the soundness of his economic position would be the surplus of the cash receipts over the cash payments during the year. Judged by his own standards he was not only making a living throughout but during the second half of the period covered by his records he was enjoying comparative prosperity.

The effect of the War upon the farmer's position is strikingly illustrated in these accounts. Although limited in the scope of his transactions by the nature and character of his holding, it is clear that he, like other farmers, large and small, was greatly affected by the economic conditions to which the War gave rise. The following figures may assist in showing the effects of these conditions upon the affairs of this small farmer :—

	Receipts.			*Payments.*			*Surplus.*		
	£	s.	d.	£	s.	d.	£	s.	d.
1. Average for whole period of 31 years	75	14	2	42	12	3	33	1	11
2. Average for 18 years up to end of 1914 .. .	65	1	10	38	9	5	26	12	5
3. Average for 16 years from 1915 to 1930	93	17	6	47	18	6	45	19	0
4. Average for 10 years from 1915 to 1924	101	13	9	45	16	0	55	17	9

Although he was materially better off on the average during the period from the outbreak of the War to the end of the record than he was before the War, it was during the years from 1915 to 1924 that the effects of the War were most clearly shown in his receipts. These were, of course, the years when farmers generally enjoyed their greatest spell of prosperity and the figures before us are a proof that the very small men shared in that prosperity to an extent that, having regard to their limited opportunities, is at once striking.

To illustrate the effect of the War on the value of individual farm products attention may be drawn to certain items in these accounts and the receipts obtained in respect of them before and after the War. The total receipts on this small farm varied a good deal from year to year, even during the War years, and it is evident that the difference between the best years and the worst

is not wholly due to the effect of the War. The worst year experienced by this farmer in the whole of the period of thirty-four years during which he kept accounts was 1911 and the best was 1920. The amounts he received in these particular years for two of the products upon which he normally depended for a considerable part of his income is shown below :—

	1911.	*1920.*
	£ s. d.	£ s. d.
Lambs sold	7 12 0	28 1 0
Eggs sold	5 8 10	31 10 11

In 1911 the price he received for his lambs was 6s. 8d. per head; in 1920 he received 25s. 6d. While his receipts from this source in 1920 were undoubtedly due to the effect of the War on the price of stock, the low figure for 1911 is partly due, no doubt, to the drought of that year.

Receipts for other products before and after the War are shown to have been as follow :—

	1911.	*1912.*	*1919.*	*1920.*
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Wool	6 2 6		14 7 0	
	(10d. per lb.)		(2s. 6d. per lb.)	
Draft Ewes ..		16 15 0		52 0 0
		(16s. 6d. per head).		(65s. per head).

The most striking rise of all as a result of the War was in the price of draft ewes. In 1920 the draft ewes and the eggs sold accounted, between them, for more than half this man's total receipts from his farm. There are items in the accounts that did not appear regularly each year and this is perfectly intelligible. And there were special items in some years that accounted for the receipts or the payments having gone up beyond what might be regarded as the normal. For example, in the flourishing year 1920, the total receipts included, in addition to the substantial sums in respect of the lambs and draft ewes already noted, the sum of £30 derived from the sale of a cow and yearling. It was unusual on this small farm to have two cattle to sell in the same year. The products which formed the regular sources of income were lambs, the draft ewes, butter and eggs. The wool was evidently not sold every year, but was often retained for two or three years and would thus account for a considerable sum among the receipts for the year in which it was sold. This, together with the sale of a cow, a heifer, or a yearling from time to time largely explains why the receipts were in some years so much above the general average.

The receipts for butter and eggs were carefully entered monthly in each year. To show how a small farmer may in

certain circumstances add materially to his income by egg-production and also to illustrate how war conditions affected in this connection the income of this particular farmer, his monthly receipts from the sale of eggs in the years 1911 and 1920 are given below :—

	1911.			1920.		
	£	s.	d.	£	s.	d.
January	0	7	6	2	8	4
February	0	6	0	1	10	10
March	0	7	6	2	3	6
April . ..	0	12	6	2	1	0
May	0	6	6	3	4	8
June	0	10	6	2	9	0
July	0	9	6	3	3	0
August	0	7	10	2	2	6
September	0	11	6	2	15	4
October	0	7	0	3	0	3
November ...	0	5	0	2	4	0
December .	0	17	6	4	8	6
	£5	8	10	£31	10	11

The difference between the total receipts in the two years is remarkable and it does not require much effort to realise what the amount of cash which his eggs alone brought him in 1920 meant to the small farmer with whose affairs we are here concerned.

It will have been observed that the annual payments given in these accounts show far less variation from year to year than do the receipts, and it may seem somewhat surprising that this farmer was enabled to keep his expenditure, even during the high-price period of the War, at much the same level as his general average. The most striking exception is the last year of all, 1930, when his payments, most unusually, were almost equal to his receipts. This is explained by the fact that he had to buy a heifer and a pony in that year, which cost him £26 5s. 0d. Had it not been for these special items, his payments and his surplus would have been of much the same order as his general average.

The regular payments shown were in respect of rent, flour for the use of the house, and Indian corn, meal and bran for the stock. There are occasional payments for clothing and boots, but there is no record of any payment for groceries. The explanation, no doubt, is that in accordance with the usual custom of the order to which this small farmer belonged, he obtained his tea, sugar and other requirements in the way of groceries, in exchange for his butter and eggs. He would, therefore, only enter in his account-book the actual cash which he took home in his pocket, this being the difference between what he received for his own produce from the tradesmen with whom he dealt and what he

had to pay these tradesmen for what he bought. It is clear that the accounts which this small farmer so carefully kept only relate to the actual cash that passed through his hands, and that the standard by which, at the end of each year, he judged his position, economically and socially, was the extent to which the money he had actually received in cheque, note or coin, was in excess of what he had to pay in discharge of his obligations. As such, the accounts which he kept are of much interest and as far as they go, they give a valuable indication of the financial circumstances of the small farmer under such conditions as those in which he lived. The standard of living, it may be said, is low and the return for the labour which the carrying on of a small farm entails, is meagre. But the estimate that is formed of the economic position of the small farmer, or small holder, depends upon the point of view of the person who makes the estimate. The living that a small farmer makes out of his holding is not to be judged from his cash transactions alone. It must be borne in mind that he feeds himself and his family—in this case, the family consisted of the farmer and his wife—to a large extent on what he produces himself, such as milk, butter, eggs, bacon and potatoes, for which he does not have to pay in cash as he would have to do had he been a wage-earner. Such was the case with the small farmer with whose transactions this article is concerned. Even in his most prosperous period from 1915 to 1924, his average profit, in the sense in which his receipts exceeded his payments, amounted to little more than £1 per week. But to him, as his accounts show, that represented very nearly a clear gain, most of which he could put by. It is obvious, however, from the very fact that he kept account of his transactions for so long a period that he was a careful man, who was intent, within his lights, on making the best of his opportunities. All small farmers are, perhaps, not what he was, but the records which he so assiduously compiled show that men like him can make a living on small farms and earn the respect of their neighbours as worthy citizens.

PASTURE MANAGEMENT AND ITS EFFECT ON THE SWARD.

By LL. IORWERTH JONES, B.Sc.

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In Volume X of this *Journal* (1) an account was given of the effect of different types of pasture management on an outrun ley consisting mostly of bent and Yorkshire fog. It was shown

that each of the various plants forming the sward was influenced by the management adopted, and the plants were grouped according to their reaction into :—

Group I : Those species which thrive best in the absence of the grazing animal.

Group II : Those species which thrive best under the influence of the grazing animal.

In the present paper an account is given of an experiment designed along similar lines, but carried out on different types of swards. This is part of a scheme started in 1929 in which the effect of management on widely different types of pastures is tested. The other areas from which critical data have been taken will be reported on later.

The two areas under consideration are situated on the Welsh Plant Breeding Station Farm, one being in Brook Field and the other in Marsh Field. Although both areas are at the bottom of a small valley and within a hundred yards of each other they differed in that :—

(a) Brook Field, though not a dry field, is far drier and better drained than Marsh Field.

(b) Their botanical composition as shown in Table I is widely different.

The fact, however, that both are "wet" areas and that rushes grow well on them is a strong point in favour of discussing both together.

History of the two Fields.

Neither of these two fields has been ploughed within living memory. Until 1924 both areas had been subjected to similar treatments, and the herbage obtained from them would be classified as rough fodder, consisting largely of rushes. From 1925 to 1929 their treatment was as follows :—

Brook Field, 1925-1928. During these four years the area was grazed during the summer week-ends by horses, and the rushes were cut twice every year. In addition, slag at the rate of 6 cwt. per acre was supplied in 1928. In 1929 the rushes were cut in March; this was followed by sheep grazing until May, and a hay crop was taken in July. By this time the rushes had decreased and the field gave the impression that it could be made into a very good pasture field.

Marsh Field. During the two years 1925 and 1926 this area was not used for any purpose, the herbage being so coarse as to be useless for any grazing. In addition, the ground was

exceptionally wet and marshy. In 1927 all the ditches bordering on this area were cleaned and also some of the pipe drains which had clogged were emptied, but no new drains were cut. In February, 1928, the whole field was burnt and the rushes were cut in May and July of that year. In 1929 the area was mown once—in July—when all the herbage was collected and burnt. The roughness of the herbage when the experiment was started in August is shown by the following figures, which give the percentage contribution of certain species as estimated from pasture cuts made at the beginning of the experiment :—

Bent	10.7 per cent.	
Yorkshire fog	19.0 per cent.	
Rushes	27.2 per cent.	59.3 per cent. coarse herbage
Molinia	22.0 per cent.	
Weeds	10.1 per cent.	
Other grasses	11.0 per cent.	

The botanical composition of the sward, as shown in Table I, indicates that :—

(1) Brook Field had a far higher percentage of the better grasses and wild white clover than Marsh Field; in fact these species formed nearly 50 per cent. of the plants in the former and less than 2 per cent. in the latter.

(2) The poorer types of grasses, bent, sweet vernal, Yorkshire fog and fine-leaved fescue were present in fair quantities on both areas.

TABLE I.

The percentage botanical composition of the two swards in August, 1929, calculated from tiller counts.

Species.	*Brook Field.*		*Marsh Field.*	
Wild white clover	4.6 per cent.	44.2 per cent.	—	
Perennial rye-grass	0.7 per cent.		—	
Rough-stalked meadow grass	35.8 per cent.		1.4 per cent.	
Crested dogstail	3.1 per cent.		—	
Bent	23.8 per cent.	47.4 per cent.	41.6 per cent.	65.0 per cent.
Yorkshire fog	12.0 per cent.		17.0 per cent.	
Sweet vernal	4.6 per cent.		2.8 per cent.	
Fine-leaved fescue	7.0 per cent.		3.6 per cent.	
Rushes	0.9 per cent.	6.1 per cent.	8.0 per cent.	33.1 per cent.
Molinia	—		12.5 per cent.	
Carex	1.3 per cent.		1.7 per cent.	
Miscellaneous weeds	3.9 per cent.		10.9 per cent.	
Other grasses	2.3 per cent.		0.5 per cent.	

(3) The coarse plants, rush,[1] *Molinia*, *Carex* and weeds formed only 6 per cent. of the sward in Brook Field, whereas in Marsh Field they constituted one-third of the sward.

Conduct of Experiment.

During the first week of August, 1929, the two areas (measuring 36 yards × 67½ yards) were divided into plots and subjected to the different types of management until the end of the 1933 grazing season. Each area was divided longitudinally into two halves, A and B, each of which was further divided transversely into nine plots. This gave nine different treatments in duplicate on both areas. The management adopted for the various plots was as follows :—

(1) Hard grazing—grazed every week in spring, summer and autumn.[2]

(2) Hard grazing in spring—grazed every week in spring but every month in summer and autumn.

(3) Hard grazing in summer—grazed every week in summer but every month in spring and autumn.

(4) Hard grazing in autumn—grazed every week in autumn but every month in spring and summer.

(5) Moderate grazing—grazed every month.

(6) Light or undergrazing—grazed every two months.

(7) Mowing, every two months, the same time as the grazing is carried out in treatment 6. This plot is further divided into :—

(a) Cut herbage removed.

(b) Cut herbage allowed to rot on the plot.

(8) Control—ungrazed—unmown.

(9) Hay—this plot is cut twice every year for hay and aftermath, and all herbage is removed.

This plan of management differs from that described in the article in Volume X of this *Journal* (1) in that there are two more plots, viz. :—

(1) Hard grazing in summer plot.

(2) Hay and aftermath plot.

The method of grazing, the intensity, and the manner of collecting data have already been described (1); it is therefore sufficient in this article to state what the different intensities signify :—

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[1] The rush in Brook Field was the common rush, while that in Marsh Field was for the most part the jointed rush.

[2] The grazing season usually extended from mid-April to mid-October, and for the purpose of this experiment, spring extended from mid-April to mid-June, summer from mid-June to mid-August, and autumn from mid-August to mid-October.

Hard grazing corresponds to 18 sheep per acre and grazed every week.

Medium grazing corresponds to 7 sheep per acre and grazed every month.

Undergrazing corresponds to 5 sheep per acre and grazed every two months.

Composition of the Swards.

Brook Field. The percentage botanical composition of the sward is shown in Table II. The first column indicates the average percentage composition of the field in 1929, the remaining five columns show the percentage composition of the different swards in 1934 after being subjected to different systems of management for four years. The plots which have been cut with the scythe have been grouped into the column " mown ", and those plots which have been subjected to hard grazing during any period of the year have also been grouped into the column " plots grazed—hard ".

The table shows that rushes and weeds only contributed about 8 per cent. of the plants forming the sward under a system of close grazing, and that they contributed over 30 per cent. of the plants forming the sward on a plot which was neither grazed nor mown. Perennial rye-grass, white clover and bent, on the other hand, formed over 35 per cent. of the plants on the hard grazed plots, while on the ungrazed-unmown plots their contribution was about 3.5 per cent. Sweet vernal contributed its highest percentage of plants on the " mown " plots and its lowest on the ungrazed-unmown. Apart from two figures—36.6 per cent. for rough-stalked meadow grass and 18.5 per cent. for fog on the ungrazed-unmown plot—Table II gives a good idea of how the percentage composition of a pasture is affected by different systems of management.

In the case of rough-stalked meadow grass and Yorkshire fog the figures 36.6 per cent. and 18.5 per cent. in the ungrazed-unmown column are very misleading. In preparing these plots for the collection of data, a strip 8ft. wide was cut across all the plots in February, 1934. The botanical analyses were made on this strip in November, 1934. This delay did not affect the botanical composition to any appreciable extent, except in the case of the ungrazed-unmown plot, which, being composed chiefly of rushes and weeds, had a large area of bare ground on which few plants could survive on account of the tall herbage. When these plants were cut down , however, rough-stalked

meadow grass and Yorkshire fog colonized the bare areas during the 1934 growing season. This is borne out by the fact that the yield of both grasses in the herbage cut on May 10th (see Table VIII) was only a fraction of their yield on any other plot, whereas their yield in September on the ungrazed-unmown plot

TABLE II.—The variation in the percentage composition of the sward in Brook Field plots in 1934 due to the different systems of management, together with percentage composition in 1929.

Species.	Average composition in 1929.	Plots grazed			Plots not grazed.	
		Hard †	Moderately	Lightly.	Mown ‡	Ungrazed-Unmown.
		Per cent.				
Perennial rye-grass ...	0.7	6.3	3.1	2.8	1.3	0.4
White clover	4.6	3.2	5.5	2.0	4.0	0.4
Bent	23.8	26.0	25.4	21.4	14.4	2.7
Crested dogstail ...	3.1	2.0	3.1	0.7	4.3	0.3
Rough-stalked meadow grass	35.8	21.3	22.6	12.4	11.3	36.6*
Yorkshire fog	12.0	17.9	12.2	19.7	24.4	18.5*
Sweet vernal	4.6	7.2	6.8	7.8	14.2	4.2
Fine-leaved fescue ...	7.0	9.3	8.7	15.6	14.2	6.0
Rushes	0.9	1.4	7.5	8.1	2.7	13.1
Weeds	5.2	1.9	4.4	1.0	5.2	17.3

* See text. † Includes all the hard grazed plots. ‡ Includes all the different types of cutting.

was practically as high as on any other. This shows that they had colonized rapidly the ungrazed-unmown plot during the year when the data were collected.

Marsh Field. Table III shows the variation in the percentage composition of the sward on plots due to the different

systems of management. From this table it is seen that *Molinia*, rushes and weeds contributed less than 6 per cent. of the total number of plants on the hard grazed plots, while they contributed nearly 50 per cent. of the plants on the ungrazed-unmown plot. Yorkshire fog and bent contributed about 85 per cent.

TABLE III.—The variation in the percentage composition of the sward in Marsh Field plots in 1934 due to the different systems of management, together with percentage composition in 1929

Species.	*Average composition in 1929.*	*Plots grazed*			*Plots not grazed.*	
		Hard.	*Moderately*	*Lightly.*	*Mown.*	*Ungrazed-Unmown.*
White clover	—	0.1	—	—	—	—
Bent	41.6	73.2	52.8	58.4	35.6	15.1*
Yorkshire fog	17.0	11.9	19.3	13.6	19.8	25.8*
Sweet vernal	2.8	1.9	2.6	9.4	7.7	0.7
Molinia	12.5	0.2	4.2	2.0	9.9	11.4
Rushes	8.0	2.3	1.6	3.5	2.3	25.2
Carex	1.7	3.7	16.7	11.2	15.3	5.9
Weeds	10.9	3.2	2.3	1.6	4.8	11.1

* See text.

of the plants on the hard grazed plot compared with only 40 per cent. on the ungrazed-unmown plot. Judging from the yield of bent and fog obtained in the first herbage cut from the ungrazed-unmown plot it is probable that these two species also colonized the bare ground on this plot during the 1934 growing

season, and that the values of 15.1 per cent. for bent and 25.8 per cent. for fog are considerably in excess of their proper value.

The reaction of the species to the different systems of management is shown to better advantage in Table IV. In computing this table the highest number of tillers per unit of area for any species is placed at 100, and the values for the other plots are calculated accordingly, so that the final figures bear the same ratio to one another as the original figures. In Tables II and III the values are expressed as percentages; as a result, the value for any species in a plot depends both on its own frequency in that plot and also on the frequency of other species; in other words, on the total number of tillers of other species. Table IV gives the relative frequency of the plants in each plot irrespective of the frequency of all other plants on that plot.

The total number of tillers per unit of area is much higher on the grazed than on the ungrazed plots. Of the grazed plots, those subjected to hard grazing have the highest number and those grazed every two months have the lowest number of tillers. Of the ungrazed plots, those which were mown have nearly 50 per cent. more tillers than the plots which were not mown.

TABLE IV.

The relative number of tillers of a number of species on the different plots in November, 1934 (average of Brook and Marsh Fields), the highest number of tillers of each species being placed at 100.

Species.	*Grazing plots.*			*No grazing.*	
	Hard.	*Moderately.*	*Lightly.*	*Mowing.*	*Ungrazed-unmown.*
Total number of tillers	100	78	73	56	38
Total grass tillers	100	69	68	51	27
Perennial rye-grass	100	43	30	16	4
Bent	100	58	61	25	5
Rough-stalked meadow grass	100	95	40	51	100(?)
Yorkshire fog	100	86	80	88	55(?)
White clover	68	100	27	61	5
Sweet vernal	63	56	100	100	17
Crested dogstail	90	86	15	100	5
Molinia	5	70	37	100	84
Rush	30	52	60	21	100
Weeds	39	41	15	4.5	100

The number of grass tillers per unit of area was also highest on the grazed plots; the hard grazed plots having by far the highest number. Of the ungrazed plots, those subjected to mowing had about half the number of grass tillers present on the hard grazed plots, whereas the ungrazed-unmown plot had only one-quarter of that number. This shows that within limits the density of a sward depends on its management, close grazing being favourable to the formation of a dense sward composed of small-tillered grasses, while under-grazing, and particularly no grazing at all, favours a more open sward with fewer but much bigger plants.

Perennial rye-grass, bent and rough-stalked meadow grass also throve best under grazing conditions, especially on areas which were never allowed to have tall herbage. On undergrazed areas perennial rye-grass and rough-stalked meadow grass have been reduced to 30 and 40 per cent. respectively on the hard grazed areas. Bent, however, has not suffered to the same degree. On the ungrazed areas the three have been reduced in number, especially on the ungrazed-unmown plot where their number is only a fraction of that on the hard grazed plot. Attention has already been drawn to the high number of tillers of rough-stalked meadow grass and fog on the ungrazed-unmown plot; this should probably only be a fraction of the number given in this table.

Yorkshire fog does not show as high a variation in its number of tillers as perennial rye-grass, bent and rough-stalked meadow grass. Although it was slightly more abundant on the grazed area this was not very marked, and it was not much more prominent on the hard grazed areas than on the under-grazed plots or the mown area.

White clover did not thrive amongst the tall herbage; on the undergrazed plot, and especially on the ungrazed-unmown plot, the number of white clover tillers was very small. According to Table IV the highest number of white clover tillers was found on the plot grazed every month, and plots grazed hard together with those mown had a smaller number of tillers. When each of the hard grazed plots is examined, however, it is found that the plot grazed hard in spring and moderately in summer and autumn had as many tillers as that grazed every month,, while the plot mown every two months and from which the cut herbage was removed had more white clover tillers than the plot grazed every month. This will be discussed later.

The maximum tiller production of sweet vernal was found on the mown areas and on the undergrazed area. On the hard grazed area the number was considerably reduced, and again on the ungrazed-unmown area it was only a fraction of that obtained on the best plots.

Crested dogtail also had its maximum tiller production on the mown areas, but, unlike sweet vernal, the number was not much lower on the hard and medium grazed plots. On the undergrazed area the number was much reduced, whereas that on the ungrazed-unmown plot was very small.

So far all the species discussed have done well under grazing conditions, and most of them had the highest number of tillers per unit of area on the hard grazed plots. Others, though they had their highest number of tillers on the mown plots, were not seriously depressed in number on the hard grazed plots. Although most of these grasses were more or less depressed on the undergrazed plots, this characteristic, without exception, was more marked on the ungrazed-unmown plot.

The last two species shown in Table IV, namely, *Molinia* and rush, have, however, reacted in an entirely different manner. These species had their highest number of tillers on the ungrazed area. On the grazed plots they were present in far smaller number on the hard grazed areas than on the medium and undergrazed areas. On the ungrazed areas they behaved differently; the rush thrived best on the ungrazed-unmown area, whereas on the mown area its numbers were reduced to about one-fifth. *Molinia*, on the other hand, had its highest number of tillers on the mown areas and was reduced to about one-third of that number of the ungrazed-unmown plot.

The figures for weeds in Table IV show that they were far more plentiful on the ungrazed-unmown plot, and least plentiful on the undergrazed plots. In this column, however, over a dozen different plants which are not grasses have been grouped together because the number of plants of each species was insufficient.

In Table V the number of plants per 10 sq. ft. of some of these weeds is given. Admitting that the number is small for deducing definite conclusions yet it is interesting in that it suggests that certain weeds (e.g. willow herb and silver weed) cannot live on hard grazed areas, whereas they do best on plots which are neither grazed nor mown. Buttercup and sorrel, on the other hand, although thriving best in the absence of the grazing animal, can withstand heavy grazing. Daisy, unlike

the previous weeds, grows best under grazing conditions, especially on the hard grazed and medium grazed areas, and was completely absent from the undergrazed and ungrazed-unmown areas. Mouse-ear chickweed showed a slight preference for the

TABLE V.

Actual number of certain weeds per 10 sq. ft. Average of Marsh and Brook Fields.

Species.	*Plots grazed*			*Plots not grazed.*	
	Hard.	*Moderately.*	*Lightly.*	*Mown.*	*Ungrazed-unmown.*
Willow herb .. .	1	—	6	13	263
Sorrel	10	4	8	31	60
Buttercup	63	74	29	51	186
Silver weed	—	3	5	4	17
Total for the above four species .. .	74	81	48	99	526
Daisy	27	31	—	9	—
Mouse-ear chickweed	21	31	2	39	32
Woodruff	33	29	16	11	35

ungrazed areas, but in the grazed areas it was least abundant on the undergrazed plots. The figures for woodruff are highest on the hard grazed and ungrazed-unmown plots and lowest on the undergrazed and mown plots.

Yield of Herbage and Variation in Botanical Composition.

During 1934 small areas of each plot were protected against grazing. The herbage on parts of these areas was cut three times during the year, *viz.* on May 10th, July 14th and October 10th; on the other parts it was cut for hay only. The results of these two systems of cutting were very similar, and on this account they have been averaged.

Brook Field. Table VI and Fig. 1 show the percentage botanical composition, by weight, of the herbage cut from these plots. Three-quarters of the herbage on the ungrazed-unmown plot was composed of rushes and weeds, the former contributing one-half and the latter one-quarter. On the hard grazed plots rushes and weeds contributed only about 6 per cent. of the total herbage, but on those where the intensity of grazing was lower, the percentage of weeds and rushes was much higher.

Taking the grasses as a whole, their highest percentage contribution was on the hard grazed plots where they formed

over 90 per cent. of the herbage. On the plots where the intensity of grazing was lower, the percentage contribution of most grasses was also lower. Certain herbage plants, such as perennial rye-grass, white clover and crested dogstail, gave no contribution to the herbage cut on the ungrazed-unmown plot, and the contribution of bent and sweet vernal was also

TABLE VI.

Percentage botanical composition (by weight) of the herbage obtained from Brook Field plots in 1934.

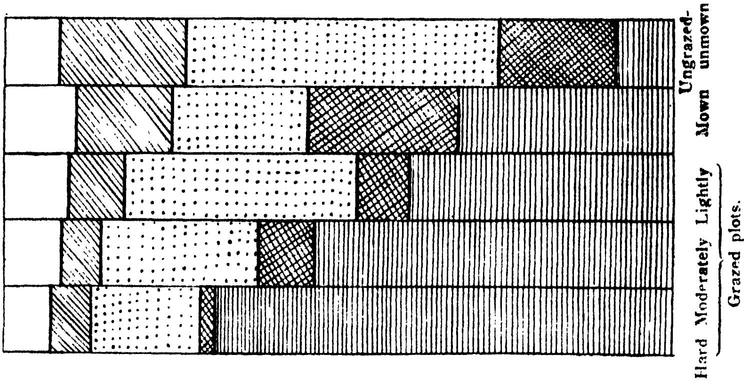
Species.	*Plots grazed*			*Plots not grazed.*	
	Hard.	*Moderately.*	*Lightly.*	*Mown.*	*Ungrazed-unmown.*
Perennial rye-grass	12.8	10.4	3.9	3.2	—
White clover .. .	2.6	2.3	1.2	2.0	—
Crested dogstail . ..	5.3	1.9	3.2	5.5	—
Rough-stalked meadow grass	11.4	5.5	4.2	8.3	5.2
Bent	19.4	14.7	16.4	8.9	1.8
Yorkshire fog	26.0	20.2	16.4	30.6	11.3
Sweet vernal	4.4	8.0	5.6	11.1	1.5
Fine-leaved fescue .	5.9	6.4	14.7	11.1	4.5
Rushes	2.6	22.6	24.0	8.1	50.0
Miscellaneous weeds	3.6	4.8	3.4	10.3	24.6

negligible. Yorkshire fog and sweet vernal gave their highest percentage contribution on the mown areas, while that of the fine-leaved fescue was much higher on the mown areas and on the undergrazed areas than on any of the other plots.

Fig. 1 shows graphically the percentage composition of the Brook Field herbage. For this purpose the better grasses and clover have been placed together in one group, and the poorer types of grasses in another group. Rushes and sedges form the third, and weeds the fourth group. The unmarked area at the top represents stubble, moss and the various grasses which were only present in small quantities. This shows that the percentage contribution of the best pasture plants was highest on the hard grazed plots, and decreased gradually as the intensity of grazing decreased, so that their contribution on the ungrazed-unmown plot was practically negligible and on this plot weeds and rushes form 75 per cent. of the herbage. The contribution of the poorer types of grasses was similar on all plots, except the ungrazed-unmown, where their percentage contribution was reduced to about one-third of the value of the other plots.

Marsh Field. The percentage contribution of certain species to the herbage cut on these plots is shown in Table VII and Fig. 2. It will be seen that the herbage cut from the hard grazed area was composed mainly of grasses, Yorkshire fog and

FIG. 2.
Showing the percentage composition (by weight) of the Marsh Field **herbage.**



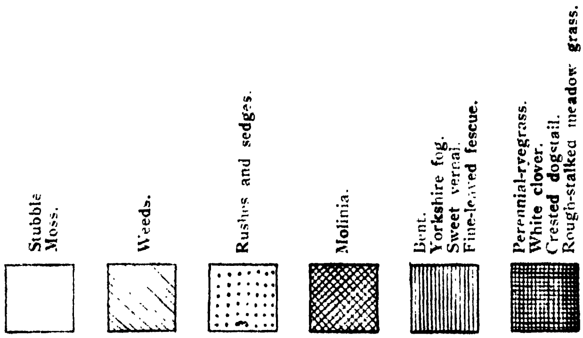
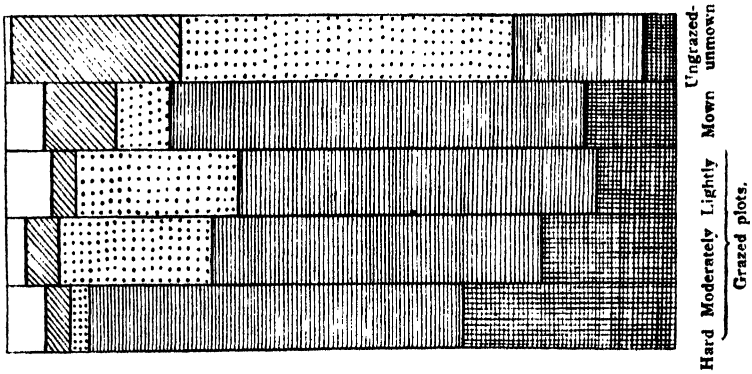


FIG. 1.
Showing the percentage composition (by weight) of the Brook Field herbage.



bent contributing two-thirds of it. On the ungrazed-unmown plot these two grasses contributed only about 7 per cent. of the

total herbage. Rushes, sedges and weeds formed 22 per cent. of the herbage on the hard grazed plot, about 48 per cent. on the undergrazed plot, and about 66 per cent. on the ungrazed-

TABLE VII.

Percentage botanical composition (by weight) of the herbage obtained from Marsh Field plots in 1934.

Species.	*Plots grazed*			*Plots not grazed.*	
	Hard.	*Moderately.*	*Lightly.*	*Mown.*	*Ungrazed-unmown.*
Bent	33.8	28.4	17.0	10.8	1.5
Yorkshire fog	31.8	15.1	17.0	15.6	5.6
Sweet vernal ...	2.7	10.2	5.4	6.0	1.5
Molinia	2.2	8.1	7.8	22.2	17.3
Rushes and sedges	16.6	23.9	35.0	20.3	47.0
Miscellaneous weeds	6.0	6.0	8.5	14.6	19.2

unmown plot. *Molinia* gave its highest percentage contribution on the mown plots, that on the ungrazed-unmown plot being a good second, but it gave its lowest contribution on the hard grazed plot. Sweet vernal gave its highest yield on the medium grazed plots and its lowest on the hard grazed and ungrazed-unmown plots.

Fig. 2 shows graphically the percentage composition of Marsh Field herbage. In this case bent, Yorkshire fog and sweet vernal form one group, *Molinia* forms another, rushes and sedges another and the various weeds the fourth group. This shows that the percentage contribution of most grasses decreased gradually as the intensity of grazing decreased, and that the percentage contribution of *Molinia*, rushes and weeds increased.

Figures 1 and 2 show how the percentage composition of the herbage depends on the method of management adopted in the previous years. If, instead of cutting, sheep had been turned on to these areas, their food on the ungrazed-unmown areas would be half rushes and weeds, very coarse with little of the finer grasses and no clover whereas on the hard grazed areas their food would consist mainly of the finer grades and white clover, only about one-tenth being rushes and weeds.

It is interesting to note that the better pasture species in both cases were favoured by hard grazing. Comparing Figs. 1 and 2 it is seen that the perennial rye-grass group of species in Fig. 1 has reacted in the same way as the bent group in Fig. 2. The bent group in Fig. 1 is similar under all treatments, except on the unmown-ungrazed plot where it was very much

reduced. This suggests that where the natural fertility is high enough for the perennial rye-grass group, undergrazing reduces this group of species but does not, except under extreme conditions, affect lower fertility demanders such as the bent group. On the other hand, where the natural fertility of an area is too low for the rye-grass group of species, undergrazing decreases the lower fertility grasses such as the bent group of species. In both cases rushes and weeds which are low fertility demanders increase and form three-fourths of the herbage on the ungrazed-unmown plots.

Relative Yield of Species.

The relative yield of species under the different systems of management is shown in Table VIII, the figures being the average for Brook and Marsh Fields.

The total yield of herbage was highest on the hard grazed plots and lowest on the ungrazed. This is probably due to the

TABLE VIII.

The relative yield (a) total yield, (b) individual yield of species under the different systems of management. Average for Brook and Marsh Fields.

Species.	Plots grazed			Plots not grazed.*	
	Hard.	*Moderately.*	*Lightly.*	*Mown.*	*Ungrazed-unmown.*
(a)					
Total yield	100	92	92	74	76
Yield of grasses (all species	100	78	68	61	23
Yield of miscellaneous weeds	26	28	27	51	100
(b)					
Perennial rye-grass	100	71	28	18	Trace.
White clover	100	77	40	53	Trace.
*Rough-stalked meadow grass	100	44	33	20	39
	(100)	(53)	(44)	(26)	(6)
Bent	100	74	62	29	5
*Yorkshire fog	100	60	55	66	25
	(100)	(78)	(67)	(68)	(4)
Crested dogstail	100	32	57	75	—
Sweet vernal	47	100	68	85	14
Fine-leaved fescue	51	46	100	60	24
Molinia	12	45	41	100	81
Rush	18	43	62	18	100

* The figures in brackets give the relative yields of rough-stalked meadow grass and Yorkshire fog in the first pasture cut, *i.e.*, before these two species had colonized the bare areas following the clearing cut on the control plot.

sheep droppings on the grazed area maintaining the soil in better fertility. In spite of the fact that close grazing weakens plants and reduces yields (2), the increased droppings on the hard grazed plots have caused a higher yield from these plots than from the other grazing plots which had not been subjected to such hard grazing. The yield of grasses also was higher on the grazed plots than on the ungrazed, and highest on the hard grazed plots; in fact the hard grazed plots gave about 30 per cent. more grass than the more lightly grazed plots, and four times as much grass as the ungrazed-unmown plot. Miscellaneous weeds (excluding rushes and sedges) yielded twice as much on the ungrazed-unmown plot as on the mown plot, and four times as much as on any of the grazed plots; the individual weeds will be referred to later. This shows that on old, wet pastures, such as those under consideration, grasses are favoured by hard grazing; weeds in general are favoured by the absence of the grazing animal, and to a greater extent by the absence of man as well.

Referring to the second part of Table VIII, it is seen that the first six species, perennial rye-grass, white clover, rough-stalked meadow grass, bent, Yorkshire fog and crested dogstail, gave their highest yield on the hard grazed plots, and their lowest on the ungrazed-unmown plot; in fact the yield of these species on the ungrazed-unmown plot was only a fraction of their respective yields on the hard grazed plots. The figures in brackets for Yorkshire fog and rough-stalked meadow grass represent the relative yields in the first pasture cut. On the grazed plots these six grasses gave their lowest yield on the undergrazed plot, and on the average this was similar to their yield on the mown areas. Comparing the mown areas with the undergrazed areas it is found that the absence of the grazing animal on the mown plots reduced the yield of rye-grass, bent and rough-stalked meadow grass, but increased that of fog, white clover and crested dogstail.

Sweet vernal gave its highest yield on the moderately grazed plot, though the mown areas were a good second; in fact, some of the mown plots gave a higher yield than the moderately grazed—this will be referred to later. The lowest yield was given on the ungrazed-unmown plots. The figures for fine-leaved fescue are similar to those for sweet vernal, with the exception that its highest yield was given on the undergrazed plot.

The figures for *Molinia* and rush are very different from

those of the grasses cited above. Both gave their highest yields on the ungrazed plots, and their lowest yields on the hard grazed areas. This shows that these two species suffer far more from grazing than they do from lack of fertility. They differ in that *Molinia* gave its highest yield on the mown areas, being about 20 per cent. higher than on the ungrazed-unmown plot, while rushes gave their highest yield on the ungrazed-unmown plot and were very greatly reduced on the mown areas. In fact the mown areas gave the same yield of rush as the hard grazed plots, and that was less than one-fifth of the amount given on the ungrazed-unmown plots.

In Section (a) of Table VIII, the relative yield of miscellaneous weeds is given. Referring to Table IX it will be seen that the various species included in this group do not react in the same way or to the same degree to the various systems of management. Most of the weeds have given their highest yield on the ungrazed-unmown plot and their lowest on the hard grazed areas. Taking the first seven weeds entered in the table it is found that each has given its highest yield on the ungrazed-unmown plot, their yield on the mown area is much lower, being about one-third of that on the ungrazed-unmown plots.

TABLE IX.

Relative yield of weeds. Average of Brook and Marsh Fields—hay and pasture.

Species.	*Plots grazed*			*Plots not grazed.*	
	Hard.	*Moderately.*	*Lightly.*	*Mown.*	*Ungrazed unmown.*
Willow herb	Trace	1	2	1	100
Sneezewort	Trace	Trace	5	8	100
Hogweed	—	—	22	45	100
Black knapweed	Trace	Trace	—	18	100
Meadowpea .. .	. . .	—	28	62	100
Lotus	8	44	—	28	100
Sorrel	22	—	2	50	100
Average of above ..	4	6	8	30	100
Thistle	12	81	43	100	69
Mouse-ear chickweed	70	29	58	100	33
Plantain	12	12	60	100	12
Buttercup	100	66	84	96	56

On averaging the grazing plots for these seven species it is noticed that the hard grazed plots gave 4 per cent., the moderately grazed 6 per cent., and the undergrazed plots 8 per

cent. of their yield on the ungrazed-unmown plot. Of the other weeds, thistle, plantain and mouse-ear chickweed gave their highest yield on the mown areas. Thistle gave its next highest yield on the ungrazed-unmown plot and its lowest on the hard grazed plots. Mouse-ear chickweed gave its second highest yield on the hard grazed plot and its lowest on the ungrazed-unmown plot and the medium grazed plot. Plantain gave its second highest yield on the undergrazed plot and its lowest yield on the hard grazed and ungrazed-unmown plots.

Unlike all the above weeds, buttercup gave its highest yield on the hard grazed areas; this was closely followed by its yield on the mown areas its lowest was obtained on the ungrazed-unmown plot.

Comparison of Mown Areas.

In Tables I–IX the figures given for the mown areas represent the average of three systems of management, *viz.* :—

(1) Plots cut for hay and aftermath (two cuts per year).

(2) Plots cut every two months (four cuts per year)

(a) Where the herbage is removed.

(b) Where the herbage is allowed to rot on the plot.

Table X gives the relative number of tillers of some of the main species on these three mown plots. The total number was highest on the plots cut every two months and from which the herbage was removed; the lowest being on the area where the herbage was allowed to rot.

White clover and bent flourished best on the plots which had been mown every two months and from which the herbage was removed; in fact the highest number of tillers of white clover (taking all plots into consideration) was found on this plot. Both species gave the poorest yield on the plots where the herbage was allowed to rot.

Sweet vernal and crested dogstail were most abundant on the hay plots and least abundant on the plots where the herbage was allowed to rot. In the case of sweet vernal, as long as the herbage was removed, cutting every two months only decreased its numbers slightly, but the decrease was very marked in the case of crested dogstail.

Rushes were very sensitive to the number of cuttings. The highest number of tillers was found on the hay and aftermath plot. On the plot cut every two months, *i.e.*, twice as often, their number had been reduced to one-tenth of this.

H

Where the herbage was allowed to rot on the plot there were four times as many rushes as on the area where it was cleared after every cut. Yorkshire fog and rough-stalked meadow grass had the highest number of tillers on the plot where the cut herbage had been allowed to rot. From this it seems as if the unremoved herbage :—

TABLE X.

Relative number of tillers of some of the main species on the three mown plots. (Average of Brook and Marsh Fields).

		Cut every two months.	
	Cut for hay and aftermath.	*Herbage removed.*	*Herbage allowed to rot on the plot.*
Total tillers	90	100	70
White clover	34	100	19
Bent	67	100	21
Sweet vernal	100	95	47
Crested dogstail	100	35	29
Rush	100	9	41
Yorkshire fog	67	85	100
Rough-stalked meadow grass	64	45	100

(1) Forms a covering which prevents evaporation of the soil moisture. It is well known that Yorkshire fog and rough-stalked meadow grass thrive better under damp conditions.

(2) The decaying herbage also probably helps rough-stalked meadow grass when it rots and turns into manure. A number of previous experiments have shown that rough-stalked meadow grass thrives best on good fertile land, especially where rotted manure or nitrogenous manures have been applied.

Table XI shows the relative yields of certain species on the three mown plots. The total yield of herbage was highest on the plot cut for hay and aftermath and lowest on the area where the herbage was mown every two months and removed. This shows that although the area cut every two months and from which the herbage was removed had the highest number of tillers, they were smaller, either naturally or through lack of fertility, so that the yield per plant was far less than on the other plots.

Rush gave its highest yield on the plot cut for hay and aftermath; its yield on the other two plots being practically the

same, and only one-fourth of that on the hay and aftermath plot.

Weeds also gave their highest yield on the hay plots, but on the plots cut every two months it was about three-fourths of this.

Crested dogstail, *Molinia*, fine-leaved fescue and bent gave their highest yield on the hay plots and their lowest on the plots where the cut herbage was allowed to rot. This was far more marked in crested dogstail than the other species.

TABLE XI.

The relative yields of certain species under different systems of mowing.

	Cut for hay and aftermath and cleared.	*Cut every two months.*	
		Cleared.	*Allowed to rot.*
Total yield	100	83	91
Rush	100	23	24
Weeds	100	74	75
Crested dogstail	100	32	16
Molinia	100	91	72
Fine-leaved fescue	100	94	91
Bent	100	91	60
White clover	44	100	46
Sweet vernal	85	100	92
Rough-stalked meadow grass	11	12	100
Yorkshire fog	67	57	100

White clover and sweet vernal gave their highest yield on the plots cut every two months, and from which the cut herbage was removed. In the case of white clover its yield on the other two plots was reduced to less than half of the amount, whereas the yield of sweet vernal was only slightly decreased on the other two plots.

Rough-stalked meadow grass and Yorkshire fog, unlike the previous species, gave their highest yields on the plot where the herbage was allowed to rot. On the other plots, the yield of rough-stalked meadow grass was only about one-tenth of this, but the yield of Yorkshire fog was reduced by between 30 and 40 per cent.

Comparison of Hard Grazed Plots.

In Tables I—IX the figures given for the hard grazed areas are the average for the four plots which had been

subjected to hard grazing. One of these plots had been hard grazed throughout the grazing season (Plot 1), while the other three had been grazed hard at different periods in the grazing season. The plot grazed hard in spring will be designated Plot 2, that grazed hard in summer Plot 3, and that grazed hard in autumn Plot 4.

Table XII shows the relative number of tillers of certain species under the four systems of hard grazing.

The total number of tillers varies, Plots 2 and 3 having the highest number of tillers and Plot 4 the lowest.

TABLE XII.

The relative number of tillers of certain species on the four systems of hard grazing.

	Plots subjected to hard grazing during			
	Grazing season. Plot 1.	*Spring. Plot 2.*	*Summer. Plot 3.*	*Autumn. Plot 4.*
Total number of tillers	93	99	100	84
Perennial rye-grass	100	64	35	72
Bent	100	96	95	62
Rough-stalked meadow grass ...	58	100	67	57
White clover	66	100	35	64
Yorkshire fog ..	84	50	81	100
Sweet vernal	24	69	70	100
Crested dogstail	9	65	99	100
Fine-leaved fescue	5	54	95	100
Rushes	8	60	32	100

Perennial rye-grass and bent had most tillers on Plot 1, and the smallest number on Plot 3 in the case of rye-grass, and Plot 4 in the case of bent.

White clover and rough-stalked meadow grass had their largest number of tillers on Plot 2; white clover had the smallest number on Plot 3, and rough-stalked meadow grass had the smallest number on Plots 1 and 4.

The other five species had more tillers on Plot 4 than on any other plot. Yorkshire fog had fewest on Plot 2, in fact it had only half as many as on Plot 4. Three of the other species, sweet vernal, crested dogstail and fine-leaved fescue had been greatly reduced in number by the continuous hard grazing on Plot 1; they were also reduced to between 30 and 40 per cent. even by the hard grazing in spring on Plot 2, whereas the number of tillers on the hard grazed plots in the summer (Plot 3) resembled more nearly the number on Plot 4.

Continuous hard grazing on Plot 1 had reduced the number of rush plants to 8 per cent. of that on Plot 4, but the number on Plot 3 had been reduced to 30 per cent. and that on Plot 2 to 60 per cent. of that on Plot 4.

Table XIII gives the relative yield of the species on the plots subjected to the four systems of hard grazing. The total yield of herbage was similar on all plots, that of the plot grazed hard all through the season (Plot 1) being about 4 per cent. less than the yields from the other three plots.

TABLE XIII.

Relative yield of the different species under the four systems of hard grazing.

	Plots subjected to hard grazing during			
	Grazing season. Plot 1.	*Spring. Plot 2.*	*Summer. Plot 3.*	*Autumn. Plot 4.*
Total yield	96	100	100	100
Perennial rye-grass	100	56	54	60
Bent	100	87	62	62
White clover	77	100	44	68
Yorkshire fog	81	79	100	88
Fine-leaved fescue	4	34	100	61
Crested dogstail	75	46	72	100
Sweet vernal	61	90	70	100
Rush	34	87	97	100

Perennial rye-grass gave its highest yield on Plot 1, but on the other three plots it gave only a little more than half of that amount. The smallest yield was given by Plot 3.

Bent also gave its highest yield on Plot 1, that on Plot 2 being a little lower, while on Plots 3 and 4 the yields were nearly 40 per cent. lower.

White clover, unlike all other species, gave its highest yield on Plot 2, and its lowest on Plot 3, this being less than half the yield given by Plot 2. Compared with Plot 2, the yield of white clover on Plot 1 had been reduced by about one-fourth, and on Plot 4 by about one-third.

Yorkshire fog gave its highest yield on Plot 3, that of Plots 1 and 2 being about 20 per cent. less, whereas that on Plot 4 was only 12 per cent. less than on Plot 3.

Fine-leaved fescue showed a very marked reaction to these four treatments. Its highest yield was given on Plot 3, but the yield on Plot 4 was 40 per cent. less. Its yield on Plot 2 was only one-third of that on Plot 3, but on Plot 1 it was almost negligible.

Crested dogstail and sweet vernal gave their highest yield on Plot 4, and whereas sweet vernal gave its lowest on Plot 1, crested dogstail gave its lowest on Plot 2.

The yield of rush was highest on Plot 4, slightly lower on Plot 3, about 13 per cent. lower on Plot 2, and on Plot 1 only one-third of that on Plot 4.

Summary and Conclusions.

An account has been given of the effect of different types of management on the botanical composition of two swards, both situated on rather wet soil, but one being a much poorer marsh than the other. From the data it is evident that each of the pasture plants forming the sward has been influenced by one or other of the various systems of management which were tested, and thus it is an easy matter to group the species according to their reaction.

Group I. In this group are placed plants which thrive best in the absence of the grazing animal. Of the plants discussed in this article, rush, *Molinia* and miscellaneous weeds fall into this group, which may be further divided according to the reaction of the species to mowing.

Rushes throve best on the ungrazed-unmown plots, and were seriously reduced in number, and especially in vigour, by cutting for hay and aftermath every year. They were still further reduced by cutting four times a year. They did well on most of the grazing plots, especially on the undergrazed, but hard grazing throughout the growing season practically killed them, while on the plot grazed hard in summer they were also reduced in number. Mature rushes are very coarse and hardly ever touched by animals, but young shoots are far more succulent. It has often been noticed that the young green shoots on the area hard grazed throughout the grazing season are nibbled at practically every grazing, and it is this that keeps them in check. However, once they are allowed to grow unhampered the stock will not touch them, but will graze in between, and eventually clumps are formed. Thus it is useless to turn a large number of animals on to any rushy area unless one is prepared to help the animals by cutting the rushes two or three times a year.

Miscellaneous weeds, taken as a group, were far more prevalent on the ungrazed-unmown plot than on any other plot; the mown areas coming in a good second. The different species, however, react differently, and whereas buttercups, daisies,

and some of the smaller species thrive best on the grazed areas, others, such as willow herb, black knapweed, hogweed, meadow pea, sneeze-wort, *Lotus major* and sorrel undoubtedly thrive best in the absence of the grazing animal combined with least interference by man.

Molinia also flourished best in the absence of the grazing animal, and on the grazed plots the harder the grazing the poorer was the stand. In this experiment this plant was rather peculiar in that it flourished better under mowing conditions than when allowed to grow indefinitely. On another area where *Molinia* thrives the indications were that it made the strongest growth on the ungrazed-unmown plot. It is very likely in the present case that the growth of *Molinia* was hampered by the growth of rushes and weeds on the ungrazed-unmown area, but the collapse of rushes under a system of mowing has given Molinia a better chance to establish itself.

From this it is seen that rushes, *Molinia* and the big coarse weeds can be largely suppressed by grazing and mowing.

Group II. This group comprises plants favoured by grazing, *e.g.*, wild white clover and most of the grasses. On the area cut for hay and aftermath white clover was present in appreciable amount, but on the ungrazed-unmown area it was practically absent. The plot which had been mown every two months and from which the herbage was removed contained the largest number of tillers per unit of area, but these were smaller than those on the ordinary grazed plots. When the cut herbage was allowed to rot on the plot the number of white clover tillers was reduced to about one-fifth. This is likely to be due to the shading effect of this rotting herbage on top of the sward. It was often noticed that the plants under this decaying herbage were yellowish and showing marked signs of etiolation. Of the grazed plots white clover was poorest on the undergrazed plots. When the number of tillers and the yield are considered it is seen that this plant has done best on the plots which were hard grazed in spring. Of the hard grazed plots white clover was poorest on the plot which was hard grazed in summer. When it is realized that white clover is a slow starter in the spring it is not surprising to find it doing so well on the plots which have been hard grazed in the spring, while it did so badly on those grazed hard in the summer. The hard grazing of the former reduces the vigour of the early growing species until the white clover has started its growth, and then all species start their summer growth together from scratch. In the plots hard grazed

in summer the early growing species have been allowed to grow during April and May, so that by the time the white clover starts nearly all the other species have a well-established growth which tends to shade it, and it is crippled still further because its active period of growth coincides with the hard grazing period, with the result that it is unable to store food or to set seed.

All the grasses found on these two areas, with the exception of *Molinia*, were more flourishing on the grazed plots than on the ungrazed, and in all cases they were least successful on the ungrazed-unmown plots. In addition, these grasses, with the exception of sweet vernal and fine-leaved fescue, throve better on the hard or medium grazed plots than on the undergrazed plots. This shows that understocking of fields of this kind, unless supplemented by the mowing machine, is bound to encourage the growth of coarse herbage to the exclusion of the finer leafy types of grasses. It was rather interesting to find that when the coarse herbage on the ungrazed-unmown plot was cut in the early part of 1934 two of the grasses, Yorkshire fog and rough-stalked meadow grass, rapidly colonized the bare areas during the growing season. This is clearly shown when the yields of these two grasses in the first herbage cut are compared with their yield for the whole year, and it suggests that they had increased in number at least ten times by the end of the season on the ungrazed-unmown plot.

It has been shown that within limits the density of a sward depends on management, close grazing being favourable to the formation of a dense sward composed of small tillered grasses, while undergrazing, and particularly no grazing at all, favours a more open sward with fewer but much bigger plants.

In conclusion it may be said that wet and marshy areas similar to the above are very sensitive to the system of management. There is no doubt that thousands of acres of this kind could be greatly improved by adopting a system of grazing and supplementing it by an occasional mowing.

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THE WINTERING OF SHEEP ON TEMPORARY GRASSES.

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On the higher hill farms the provision of winter keep is one of the most serious problems with which the farmer has to contend. In many cases the amount paid by the hill farmer for wintering the younger portion of his stock in the lowlands exceeds the actual rent of his farm.

For a number of years this problem has been receiving considerable attention from Professor Stapledon, and, at a Grassland Conference held at Aberystwyth in 1928, he suggested that it would be worth while to lay down experiments with a view to evolving a system of sheep wintering under which the animals would be allowed to graze for a certain period each day, say two hours, on young succulent grass, the remainder of the twenty-four hours being spent on a rough pasture. Professor Stapledon also suggested that special crops of hardy winter-green grasses might be grown for this purpose.

With the end in view of testing out this idea, an experiment, run in conjunction with Imperial Chemical Industries Ltd., was laid down in 1929 at Egryn, Dyffryn, Merionethshire (1). The underlying idea of this experiment was to assess the merits of Italian rye grass as winter keep, when grazed on the system outlined above. In the spring of 1929 a three-acre stubble field was ploughed up and dressed with thirty-two per cent. basic slag at the rate of 5 cwt. per acre. During the last week of April the field was cultivated and sown down in three plots of one acre each; the seeds mixture for each plot being made up of 40 lb. of Italian rye-grass and 2 lb. of wild white clover per acre. In addition, on Plot 1 only, rape, at the rate of 5 lb. per acre, was sown as a nurse crop. By the middle of August Plot 1 had fattened twenty wether lambs, and Plots 2 and 3 had yielded a light hay crop of about 12 cwt. per acre. During September the aftermath of all three plots was grazed with ewes for flushing, and on 1st October the plots were closed up and dressed with 1 cwt. per acre of nitro-chalk. The autumn of 1929 was mild and the plots made good growth, and, on 27th December, when grazing commenced on Plot 1, there was a good thick sward of Italian rye-grass, six to eight inches in height. From this date until the 5th April, thirty-five sheep were wintered

on these plots. The sheep were turned on to the Italian rye-grass for two hours per day, the remainder of the twenty-four hours being spent on an adjoining block of rough pasture. Grazing on Plot 8 did not commence until the 14th March, and when it terminated, on 5th April, at least one-half of the herbage originally present remained. It was estimated that for the period 27th December to 5th April, the three acres of Italian rye-grass, together with the rough pasture, would have kept at least forty sheep.

The Cahn Hill Improvement Scheme was inaugurated early in 1933 and possession was taken of part of the lands on the 25th March of that year. From the beginning it was realised that this question of providing winter keep for sheep was one of the fundamental problems that had to be dealt with. The information already available was considered sufficient to justify the growing of Italian rye-grass for winter keep, and it was also decided to try out an experimental field of timothy grass, sown in rows, for the same purpose. This species was chosen because of its proven winter-greenness and palatability (2). The method of sowing was adopted, firstly, because experience with this grass in Wales has shown that when broadcast as a pure species the resulting sward is very apt to become weed infested (3), and secondly, because it has been shown that grass, when sown in rows, makes more vigorous growth and has a higher protein content than the same species sown broadcast (4). At the beginning of May a fourteen-acre field of low fertility, at an altitude of 750 feet, was ploughed up, cultivated, manured with 6 cwt. thirty-two per cent. basic slag and 1 cwt. nitro-chalk per acre, and sown down on the 28th of the month with oats and 28 lb. per acre of Italian rye-grass. The oats were harvested in September and, on account of the late sowing and the foul condition of the land, only half a normal sward of Italian rye-grass was obtained. Also during May, seven acres of land at an elevation of 850 feet, ploughed up during the previous winter after a root crop, were cultivated, manured with 6 cwt. thirty-two per cent. basic slag and 1 cwt. nitro-chalk per acre, and sown down with indigenous timothy, bred by the Welsh Plant Breeding Station. The seed was sown at the rate of 8 lb. per acre with a Planet Junior drill in rows eighteen inches apart. Mustard seed at the rate of 1 lb. per acre was sown with the timothy; this plant acts as an indicator and so enables cleaning operations to be carried out at an early date after germination. A month after sowing the rows were scufflled with the auto-culto and they were subsequently horse hoed at intervals during the summer.

In October about one-half of the area was run over lightly with the mower and the produce converted into A.I.V. silage of excellent quality.

At Michaelmas, 1933, the mountain sheep walk of Nant Rhys, together with the stock it carried, was taken over by the Cahn Hill Improvement Scheme. Included in this flock were 400 lambs and these were brought down to Pwllpeiran, the home farm, at the end of October : 290 of the best were sent away to winter on lowland farms, nineteen were sold, and ninety-one remained to winter at Pwllpeiran. On the 12th November these ninety-one lambs were turned to graze on an old ten-acre pasture adjoining the timothy rows, on to which they were turned for two hours daily. Grazing on this system continued until 12th February when the lambs were changed to a poor hill pasture, from which they were turned to the Italian rye-grass field for one and a half hours daily. (Prior to this eleven store cattle had been grazing on the Italian rye-grass during the period 23rd November to 30th December (inclusive)). The lambs continued grazing on this area until 26th March, the weather during this period being very dry and cold, and keep extremely scarce. Owing to this scarcity of keep, and to the increasing number of weakly ewes being brought down from Nant Rhys, it was then decided to turn the lambs to the poor hill pastures for the period remaining before their return to Nant Rhys. A fortnight before these lambs were removed from the Italian rye-grass field, fifty weakly ewes from Nant Rhys were turned in, and continued grazing there for nine weeks. The timothy rows, after the lambs had been moved to the Italian rye-grass, were rested for three weeks and on 5th March, 120 weakly ewes, brought down from Nant Rhys, commenced grazing on them, together with the adjoining ten acres of pasture. In this case no daily period on the grass rows was given, but the gate between the two fields was left open so that the ewes had constant access to the timothy on which they spent the greater part of the day. The ewes continued grazing on this system for six weeks.

At the end of March, when all the home-wintered lambs had finished grazing on the two blocks of temporary grasses, the lambs wintering away were inspected. Although the 290 lambs had been divided up among the various farms in as equal lots as possible, there was some variation in their condition; this was due mainly to two factors, the difference in quality of the various pastures, and the varying extent of the land over which the lambs could roam. All the lambs had done well, those on a farm in the Llangeitho district having done best. A comparison was

made between the latter and the home-wintered lambs (the original culls), and it would be safe to say that the home-wintered batch had at least caught up the Llangeitho wintered lambs and compared well with them in size, vigour and bloom. During the wintering period the lambs grazed on the timothy and Italian rye-grass had undoubtedly made more growth than any of the lambs wintered away from Pwllpeiran.

Assessment of Value.

The system of wintering described above was essentially of an experimental nature; information on the practical value of timothy for this purpose being very meagre. In consequence, at this stage, any attempt to cost the system on a commercial basis would be premature. The only assessment of value that can usefully be made here consists of an account of the grazing days obtained from the two areas. It should, however, be stated that the customary charge made by lowland farmers in Mid-Wales for wintering sheep or lambs is in the neighbourhood of 6/- per head for the period mid-October to mid-April, (twenty-six weeks). During this period of the year the grazing requirements of a ewe and an April born lamb are approximately the same.

Dealing first with the timothy rows and the permanent pasture, it can be said that the ten acres of permanent pasture, if grazed alone, would have carried, at the highest estimate, twenty sheep throughout the six winter months. This is equivalent to 3,640 grazing days. (By a " grazing day " it is meant that one sheep or one lamb has been on the area for twenty-four hours). This area can now be dealt with as consisting entirely of the timothy rows, 3,640 grazing days being deducted before the final total is arrived at. Ninety-one lambs were grazing for thirteen weeks, which is equivalent to 8,281 grazing days; and 120 sheep were grazing for six weeks, an equivalent of 5,040 grazing days. This gives a total of 13,321 *less* 3,640, that is 9,681 grazing days have been obtained during the winter from seven acres of timothy rows.

The Italian rye-grass field provided keep for the following stock :—Ninety-one lambs for six weeks, or 3,822 grazing days (the grazing of the lambs on the hill pasture can be ignored, heavy grazing causing great improvement to such areas); fifty sheep for nine weeks, or 3,150 grazing days; and eleven cattle for thirty-eight days, which, (assuming the grazing of a beast over two years old to be equal to that of seven sheep), is equivalent to 2,926 grazing days. This gives a total for the Italian rye-grass area of 9,898 grazing days; these being obtained, as

mentioned previously, from a crop of less than half the normal bulk.

The total of grazing days during the winter for the two areas was 19,579, or, if the timothy rows and permanent pasture be counted as one unit, 23,219.

In conclusion, it can be said that this system of rationing young grass for winter keep has proved of considerable value. Not only did the lambs thrive exceedingly well during the winter, but they also held their own with the away-wintered lambs when both lots were sent back to the mountain. All the home-wintered lambs were tattooed and thus their progress during subsequent years can be watched. At a conservative estimate, it can be said that the seven acres of timothy rows, together with the adjoining block of pasture, would keep seventy lambs throughout the winter. To all appearances the timothy rows are better this year than they were in 1933; as yet there are no signs whatever of deterioration. During the summer of 1934 they were cut for hay and yielded one ton per acre of excellent quality hay. Immediately the hay had been cleared from the field, 1 cwt. per acre of C.C.F. No. 4 fertiliser was applied.

On the other hand it has been fairly definitely established that Italian rye-grass, unless it be re-sown, is not a success in its second year.

Further experiments on similar lines are being carried on this year.

Acknowledgments.

We desire to express our thanks to Professor Stapledon, C.B.E., M.A., at whose instigation the work was begun and under whose direction it has been carried on. Thanks are also due to Mr. Gwilym Evans, B.Sc., for his supervision of the sowing and subsequent treatment of the timothy area.

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A COMPARISON OF THE COMPOSITION OF HILL SWARDS UNDER CONTROLLED AND FREE GRAZING CONDITIONS.

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An experiment designed to study the effect of manures and controlled grazing was commenced in 1930 at two hill farms near Aberystwyth, the results of which have been reported upon (1). At the same time, unfenced plots at each centre were given similar manures, and the degree of grazing and botanical change on each plot was investigated (2).

The present report deals with the botanical composition of the swards of these fenced and unfenced plots.

The Experiment (E.117).

The investigated swards were :—

1. An open-hill fescue-*Agrostis* pasture (Llety-fescue).
2. An open-hill *Molinia* pasture (Llety-*Molinia*).
3. An enclosed hill fescue-*Agrostis* pasture (Bwlchrosser).

The trial consisted of five fenced 1/100th acre plots at each centre. These plots were treated as follows :—

(1) Lime was applied at the rate of 2 tons per acre of calcium carbonate.

(2) Superphosphate was applied at the rate of 4 cwt. per acre.

(3) Superphosphate was applied as above, with the addition of kainit and sulphate of ammonia at 4 cwt. and 1 cwt. per acre respectively.

(4) As Plot 3, but with the addition of lime at the above rate.

(5) A control plot, grazed, but receiving no manures.

These plots will be referred to as Ca, P, PKN, CaPKN and Control. The plots were replicated outside the fenced area at each centre for the free grazing data.

The initial application of manures was made in the spring of 1930. The plots subsequently received each spring superphosphate, kainit and sulphate of ammonia in similar quantities to the above. In addition, sulphate of ammonia at ½ cwt. per acre was applied to the PKN and CaPKN plots at monthly intervals from April to September. The fenced plots were grazed monthly, six grazings being made per season.

Results.

In July, 1934, four years after the experiment was started, an analysis was made of the herbage on a percentage tiller estimation

TABLE I.

The Composition of the herbage at the Bwlchrosser and Llety-fescue centres based on a percentage tiller estimation.

Centre and plot.	*Position.*	*Fine-leaved fescue.*	*Bent (Agrostis species).*	*Sweet vernal.*	*Other grasses.*	*Wild white clover.*	*Miscellaneous species.*	*No. of tillers per 6in. x 6in.*	*Per cent. bare ground.*
Bwlchrosser.									
CaPKN	Fenced	65½	23	Trace	11	½	—	495	4½
	Open	52½	41	1	1½	3½	½	775	½
PKN	Fenced	20	75½	—	4½	—	—	490	8
	Open	47½	47½	½	3½	—	1	745	Trace
Ca	Fenced	47½	29	—	20	1	2½	495	7½
	Open	46½	42½	3½	3	1	3½	500	6
P	Fenced	45	47½	2	½	1½	3½	533	10
	Open	38	51½	½	2	5	3	525	2½
Control	Fenced	50½	42	1½	1½	½	4	468	9½
	Open	58½	34	½	2½	Trace	4½	655	2
Llety-fescue									
CaPKN	Fenced	17	83	—	—	—	—	405	9
	Open	63	36½	—	—	—	½	690	1
PKN	Fenced	26½	68½	5	—	—	—	450	18
	Open	79	21	Trace	—	—	Trace	630	5½
Ca	Fenced	42½	54½	1	—	—	2	520	5
	Open	70	25½	1½	½	—	2½	585	2
P	Fenced	36	61	½	—	—	2½	535	2½
	Open	79	16½	—	3	—	1½	650	½
Control	Fenced	53	37	Trace	—	—	10	385	6½
	Open	63	32½	—	1½	—	3	570	6½

Other grasses = *Triodia decumbens*, Yorkshire fog and smooth-stalked meadow grass.
Miscellaneous species = *Potentilla erecta*, *Galium saxatile*, field woodrush, bilberry, mouse-ear chickweed and *Carex* spp.

basis. The data from the Bwlchrosser and Llety-fescue centres are presented in Table I, and those for Llety-*Molinia* in Table II.

TABLE II.

The composition of the herbage at the Llety-Molinia centre based on a percentage tiller estimation.

Plot.	*Position.*	*Fine-leaved fescue.*	*Bent* (Agrostis *species*).	Molinia caerulea.	Nardus stricta.	*Other grasses.*	*Miscellaneous species.*	*No. of tillers per 6in. x 6in.*	*Per cent. bare ground.*
CaPKN	Fenced	39½	59	Trace	1½	Trace	—	685	11
	Open	58½	8½	23	10	Trace	Trace	450	11
PKN	Fenced	26	74	—	—	Trace	—	650	11½
	Open	10	9	74	7	Trace	Trace	189	29½
Ca	Fenced	73	9	11	6½	—	½	555	9½
	Open	55	5	38	1	Trace	1	326	8½
P	Fenced	54	35½	8	2½	Trace	Trace	715	6½
	Open	60	½	34	4	Trace	1½	418	7½
Control ...	Fenced	59	17	5½	15½	Trace	3	515	8½
	Open	20½	4	50	20½	Trace	5	307	19½

Other grasses = *Poa annua*, Yorkshire fog and *Trioda decumbens*.

Miscellaneous species = *Potentilla erecta*, *Galium saxatile*, *bilberry*, field woodrush, heath rush, *Carex* species and *Scirpus* species.

As additional data an analysis was made on plots cut for hay and aftermath, and attached to the Llety centres. These results are shown in Table III.

Referring to Table I it will be observed that bent (*Agrostis* species) and fine-leaved fescue form the bulk of the herbage, and at the Llety-fescue centre the preponderance of bent over fescue in the fenced plots, as compared with the open plots, is very marked except in the case of the control plot. Such is not the case, however, in the more mixed herbage of Bwlchrosser.

The relative abundance of white clover tillers on the open plots of CaPKN and P at Bwlchrosser would be accounted for by the fact that these unfenced plots were continually closely grazed by sheep and bullocks.

More miscellaneous species occurred in the herbage of the control plots than in that of the Ca and P plots, while the CaPKN and PKN plots had least of all.

The denser swards in the open plots at both centres are made evident by the higher number of tillers per mesh and less bare ground.

Referring next to the Llety-*Molinia* centre (Table II) there is much more *Molinia* in the herbage of the open plots, especially in the case of the CaPKN and PKN plots where the amount of Molinia in the fenced plots is negligible.

The proportion of bent to fescue in the fenced plots is interesting. In the CaPKN and PKN plots, where the greatest change was made under the influence of manures and controlled grazing, the bent exceeded the fescue, but not in the remaining plots.

The proportion of *Nardus* to the other species is higher in the open plots, except in the Ca plot. The large amount in the herbage of both control plots is worthy of note.

The relative density of these plots at the *Molinia* centre is in the opposite order to those of the other centres, for here the fenced plots show the greater density. This is a reflection on the proportion of highly tillering bent and fescue in the herbage of the fenced plots compared with the greater proportion of *Molinia* in the open plots. The relatively few tillers and the large amount of bare ground for the open PKN plot is accounted for by the herbage of this plot not having entirely recovered from the effect of a heavy spring dressing of sulphate of ammonia applied under circumstances which caused the herbage to burn.

The data from the plots cut for hay and aftermath (Table III) show that there was a far greater proportion of bent tillers to fine-leaved fescue tillers on the manured plots, compared with the control plots at each centre. Also, at the *Molinia* centre the proportion of *Molinia* was greater on the control plot than on the manured plot.

There was only a small percentage of miscellaneous species present in these cut plots, but the control plots contained the greater proportion.

TABLE III.

The composition of the herbage cut for hay and aftermath based on a percentage tiller estimation.

Centre and plot.	*Fine-leaved fescue.*	*Bent* (Agrostis *species*).	Molinia caerulea.	Nardus stricta.	*Other grasses*	*Miscellaneous species*	*No. of tillers per 6in. x 6in.*	*Per cent. bare ground.*
Llety-fescue								
CaPKN	15½	84	—	—	Trace	½	328	22
Control	56½	41½	—	—	½	1½	480	23
Llety-Molinia								
CaPKN	55	30	12	2½	Trace	½	475	14
Control	49	1½	44½	3	Trace	2	378	20

In regard to density of herbage the relationships of manured to control were different for the two sward types.

Discussion.

The data indicate that the effect of controlled grazing upon the botanical composition of the herbage has been different from that of uncontrolled grazing. This effect, however, has been more marked at the high-lying Llety centres than on the more sheltered Bwlchrosser pasture containing a more mixed herbage.

The changes were that in the fenced plots receiving CaPKN and PKN manures bent became the dominant species over fescue, but that in the open plots the opposite was the case. These changes also took place in the Ca and P plots at the Llety-fescue centre. In addition, at the Llety-*Molinia* centre, the proportion of *Molinia* in the herbage of all the fenced plots was small in comparison with the open plots.

The progressive contribution of bent to the yield at the two fescue centres, and of bent plus fescue to the yield at the *Molinia* centre over four years of experiment has been illustrated in the report on the fenced plots (1).

A previous analysis of the open plots (2) showed that two years after the initial application of the manures fescue was increasing in the herbage of the Llety-fescue plots.

The data appear to show that bent is more responsive to the effects of higher fertility and close periodic grazing than is fine-leaved fescue, and that periodic grazing alone and unaccompanied by complete manuring is not sufficient. The same

manuring on the open plots has not increased the bent. That these open plots have been well grazed for several years has been previously shown (2), but the fact that their herbage has not been grazed off to the base at regular intervals has evidently encouraged the fescue rather than the bent. That the change from a *Molinia* sward to a bent-fescue sward at the *Molinia* centre has been more complete on the fenced plots than on the open plots is apparently accounted for by this same factor. It is significant that the data obtained by Jenkin (3) from similar pastures in North Wales showed that an improvement was accompanied by an increase of bent in the herbage.

Other work on similar swards has shown that individual manures can have a marked effect upon botanical composition. Thus Jenkin found that Gafsa phosphate gave superior results to either basic slag or superphosphate, but that basic slag was decidedly better than superphosphate, while Jones (4) found that nitro-chalk gave a marked increase in the yield of bent as compared with sulphate of ammonia. Davies and Jones (5) found that nitrogen favoured the grasses and that phosphate had a greater effect upon the clovers than upon other constituents of the herbage. In the present trial P and CaPKN gave the highest percentage of tillers of white clover at Bwlchrosser, but it is significant that the PKN plots were the only ones without clover. It is evident that the effect of the nitrogen in the PKN has so influenced the grasses that the clover has been unable to make a stand, but that in the case of the CaPKN plot, the presence of both lime and phosphate has had a counterbalancing effect.

The investigations of Stapledon and Thomas (6) showed that Yorkshire fog was increased under PKN on a hill sward. This has also been the case at Bwlchrosser, but here smooth-stalked meadow grass has also made considerable increases.

The lower proportion of tillers of miscellaneous species in the herbage which has received nitrogen corresponds with the lower yield of these species under this manure reported upon by Stapledon and Thomas (6) and Davies and Jones (5).

In regard to the cut plots, the data show the same botanical changes as in the corresponding fenced, but grazed plots, with the exception that although the *Molinia* has decreased considerably in the manured plot compared with the control, there yet remained 12 per cent. of *Molinia* in the CaPKN cut plot as compared with only a trace in the corresponding grazed plot.

In conclusion a statement made in the report on the fenced plots (1) may be reiterated, namely, that the ascendancy of

bent over fine-leaved fescue is a desirable change in the composition of hill pastures, for bent makes a greater response to methods of improvement than does fescue, and bent has proved to be the more palatable of the two grasses (7).

Acknowledgments.

The writer desires to thank Professor R. G. Stapledon, C.B.E., M.A., at whose instigation these comparisons were made.

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COMPARISON OF (A) AN OLD WITH A TEMPORARY PASTURE, AND (B) TWO TEMPORARY PASTURES,

FROM ONE OF WHICH WILD WHITE CLOVER HAD BEEN OMITTED AT SEEDING DOWN.

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In an earlier volume of this *Journal* (Vol. VIII, 1932), a progress report was made on an experiment at the College Farm, Aber, in which certain pastures are being compared by means of the live weight increments of stock put on to graze them. The pastures consist of (*a*) a seven acre field which has been under grass for at least sixty years, and which has always been regarded as a good pasture; (*b*) two temporary pastures, each of four acres, and laid down in 1927. The two temporary grass fields, which had been obtained by dividing an eight acre field

into two equal and similar portions, have received identical treatment and management, the only difference being that wild white

TABLE I.

Live Weight Increase per Acre given by each class of stock, and the average increase per head.

Year.	Temporary Pasture. Wild white. Ewes.	Lambs.	Wethers.	Cattle.	Total.	Temporary Pasture. No wild white. Ewes.	Lambs.	Wethers.	Cattle.	Total.	Permanent Pasture. Ewes.	Lambs.	Wethers.	Cattle.	Total.
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
1930. Increase per acre	91	173	40	290	594	58	129	18	233	438	—	—	—	—	—
Av. increase per head	18.3	34.6	7.9	248		14.3	32.2	6.2	233		—	—	—	—	—
1931. Increase per acre	61	142	76	217	496	48	108	56	192	404	21	103	42	172	341
Av. increase per head	12.1	28.5	12.6	289		12.2	27.0	12.5	256		7.4	26.7	7.7	301	
1932. Increase per acre	76	166	76	112	430	72	133	65	88	358	69	132	38	71	310
Av. increase per head	14.8	31.2	12.7	202		18.3	30.5	12.9	188		16.5	30.0	9.5	208	
1933. Increase per acre	69	138	8	163	378	52	114	15	68	249	51	107	—1	84	241
Av. increase per head	11.4	23.1	2.0	163		10.8	23.2	3.8	68		13.8	22.4	—0.3	84	
1934. Increase per acre	74	135	62	212	483	63	109	45	228	445	56	95	39	191	381
Av. increase per head	15.2	27.0	11.7	212		15.7	27.2	11.7	204		14.0	23.8	9.8	191	
Total increase per acre for whole period	371	754	262	994	2381	293	593	199	809	1894	200	437	118	518	1273
Average increase per acre per annum	74	151	52	199	476	59	119	40	162	379	50	109	29	129	318

clover at the rate of 1 lb. to the acre was included as seeding down one and omitted from the other.

The comparison of the two temporary pastures began in 1930, and the field of old grass was brought into the experiment in 1931. The trial extended in each season from early in May until about the end of October. An attempt has been made throughout at stocking the plots according to the amount of growth, thus minimising the possibility of vitiating the results through overstocking or understocking. Cattle of from one to two years of age were left on the plots throughout the period of the trial in each season. Welsh ewes, each with one lamb by a Welsh ram, were put on the pastures in early May, and remained until the lambs were fit for sale to the butcher, *i.e.*, until about the middle of July. The ewes and lambs were then taken off the plots, which were left free of sheep for two or three weeks. About the beginning of August, Welsh Mountain wether lambs from the hill land were put on the pastures, where they remained until the close of the grazing season.

A. Comparison of a Temporary and a Permanent Pasture.

In this comparison the field in which wild white clover had been included was regarded as the typical temporary pasture, as it represented the type of this grazing found on the farm. Table I shows the live weight increases in each season, these being expressed as total gain per acre, and also showing the proportion of this gain contributed by each class of stock. Below the latter figure, and in the same division of the table, is given the average live weight increase per head of each class of stock.

Live weight increase per acre.

It is evident that, in each year, the temporary was distinctly superior to the permanent pasture in live weight increase per acre. If the increase from the old pasture is put at 100 in each year, that from the new becomes 146, 140, 156 and 127 in the years 1931, 1932, 1933 and 1934 respectively; taking the four grazing seasons together, the temporary has yielded 40 per cent. more live weight gain than the permanent pasture. The superiority of the temporary grass in 1934 is not adequately represented by these figures, as undoubtedly this plot was insufficiently stocked in the second half of the grazing season.

The superior live weight gains of the temporary pasture was brought about by a larger stock carrying capacity and, to a less extent, by greater increases in the weights of individual animals. The greater capacity of the former for carrying stock is seen from the fact that, in the first part of the season, it held five ewes and

five lambs to the acre against four on the old pasture. In the latter half of the season the numbers of wether lambs were six and four respectively on the two pastures.

Differences as represented by average increase per head of stock.

As regards the greater individual live weight increases referred to above, Table I shows that the lambs put on slightly more weight each year on the new pasture; this, however, is in spite of the fact that sheep are sensitive to overstocking, and that this pasture carried one ewe and one lamb more to the acre than the old pasture. The cattle and the ewes varied, their average increase in weight being sometimes rather greater in the old and sometimes greater in the new pasture. The greatest difference, however, was found in the wether lambs introduced on the plots in the latter half of the season. The difference in the behaviour of this class of stock has constituted the most interesting difference between the two pastures. Wether lambs, averaging about 45 lb. live weight, were put on the plots towards the end of July. The lambs continued to thrive equally well on both pastures for about a month, but afterwards those on the new pasture drew ahead, the difference between the two lots widening as the end of the season approached, although there was neither scarcity nor excess of grass on either field. In 1931, the year when this difference was most clear, the lambs increased from an average of 45 to 53 lb. for the first month. By the end of the second month those on the temporary pasture had gained another 2.5 lb., while those on the other pasture gained only 0.6 lb. By the end of September the wethers on the former field had put on a further 0.5 lb., while those on the old pasture had lost weight, being only the same weight as they were in the middle of August.

The difference which becomes manifest in September and October in the condition of the wether lambs is usually readily discernible without the use of the weighing machine; those on the old pasture become thinner, and their wool forms a parting along the middle of the back.

Investigation of cause of failure of lambs to thrive in autumn on the permanent pasture.

This effect is not confined to the old pasture at the College Farm. Cases have been met in Anglesey, Denbighshire and Flintshire, where lambs do not thrive after about the middle of August; this is reflected in the large proportion of culls, and in the difficulty of getting these into a marketable condition. It is possible that the cause may not be the same in all cases. The

failure of the old pasture to maintain the lambs in a thriving condition may be due to parasitic infestation, or to a nutritional deficiency. It is well known that lambs are very susceptible to certain stomach worms, and moreover, the attack would make itself felt about the same time as the loss of condition in this case. The view that this condition is caused by worms also finds support in the fact that even after removing the lambs from the old pasture to a field of fresh young grass, considerable time elapses before they begin to improve. Counts of nematode eggs in samples of faeces of the lambs have indicated a rather heavier infestation among those grazing the old pasture. The problem, however, is difficult to tackle by determining the extent of infestation because lambs which are inadequately nourished are more subject to infestation with internal parasites than lambs on a normal plane of nutrition; it is thus difficult to determine whether the poor condition is the result or the cause of the worm infestation.

Indirect evidence also exists supporting the view that the lack of condition of the lambs on the old grass may be due to mineral deficiency. It is known that bent grass and Yorkshire fog, common constituents of many old pastures, are deficient in minerals, the former being low in lime and the latter in phosphoric acid. Furthermore, the proportion of both these grasses is known to increase in pastures towards the autumn, and this would correspond to the time when the lambs lose condition. Thus, the proportion of bent in this old pasture increased from 24.8 per cent. in the spring of 1934 to 66.5 per cent. in October, while in the temporary pasture there was only a trace of this constituent in both spring and autumn. To find whether mineral deficiency is the cause of the trouble, it was decided to apply mineral manures to a portion of the old grass and observe whether the lambs on that portion would thrive as well as those on the temporary pasture. Accordingly, two plots, each of three acres, were fenced off from the old pasture in January, 1934, and one of these was dressed with 1 ton of ground limestone, 5 cwt. slag, and 3 cwt. of kainit to the acre. The low rainfall in the first half of the year was unfavourable to the action of the manures in that year. Unlike the three preceding years of the trial, the lambs on the old pasture, both manured and unmanured, continued to thrive, but there was an indication that, by the time of the last weighing, those on the unmanured section were falling behind those on the manured plot and those on the temporary pasture. The differences in the weights on October 16th, as seen in Table II, are not significant, and the trial must

be extended for at least one more grazing season before it can be decided whether the mineral dressing causes the old pasture to support lambs in a thriving condition throughout the grazing season. Should the manurial dressing attain this result, its success may be due to a decrease in the herbage of the proportions of mineral deficient plants, like bent, or to a general raising of the mineral content of most of the plants constituting the herbage. Table II shows that there were only traces of bent in the temporary pasture in both May and October. In the old pasture, the proportion of this constituent increased from 24.8 per cent. to 66.5 per cent. from May to October in the unmanured portion, whereas it increased to only 27.8 per cent. in the manured section. The trial is in an inconclusive stage, but it is possible that an old pasture may retain many of the qualities of a temporary pasture provided the proportion of bent can be kept down.

TABLE II.

Pasture.	*% Bent May, 1934.*	*% Bent Oct., 1934.*	*Average weight of lambs (lb.).*		
			July 26.	*Sept. 21.*	*Oct. 16.*
Temporary	Trace	Trace	44.6	53.9	56.3
Permanent, manured	24.8	27.8	46.7	55.8	57.8
Permanent, unmanured	24.8	66.5	46.4	55.0	56.2

B. Effect of omitting wild white clover when seeding down.

Botanical Composition of herbage of plots.

The temporary pastures, sown in 1927, and comparable in treatment and management except that wild white clover was omitted as seeding down one of them, were compared by means of botanical analysis of the herbage, and by observing and weighing the stock grazing these plots.

An examination of the herbage of the plots carried out by walking over and inspecting the grass, convinces the average observer that the wild white clover plot appears as if it would hold more stock than the plot in which none of this ingredient was sown. This is due to the closer appearance of the turf of the former, and to fewer daisies. Botanical analyses and observation have shown that the wild white clover plot has always contained more of this species in the herbage despite the colonies of indigenous white clover which have appeared in the other plot. Table III gives the result of the botanical analysis of the herbage carried out in May, 1934; the old pasture is also included in this table.

TABLE III.

(Composition of Herbage in percentage weight).

	Wild white clover plot.	*No wild white plot.*	*Old pasture.*
Perennial rye-grass	58.9	66.4	9.9
Wild white clover	22.4	12.4	10.7
Rough-stalked meadowgrass	2.5	3.2	—
Timothy	0.4	0.5	—
Cocksfoot	0.5	0.3	5.2
Crested dogstail	—	—	7.0
Yorkshire fog	3.9	6.3	9.3
Bent	0.9	0.3	24.8
Red fescue	—	—	8.9
Moss	—	—	7.8
Miscellaneous weeds	10.5	9.6	16.4
	100.0	100.0	100.0

Thus, seven years after seeding down, the proportion of wild white clover is nearly twice as much in the plot in which it was included when seeding down, as in the other section. At other times of the year the proportion of weeds estimated as walking over the pastures certainly appears to be higher in the no wild white plot, and in April, when daisies are in flower and very conspicuous, the no wild white clover plot appears to be much more heavily infested with this weed.

Table I gives the results of comparing the two pastures by means of live weight increases of the stock grazing them. It is seen that the wild white clover plot has been clearly superior to the other each year. If the live weight increase per acre on the no wild white clover plot is expressed as 100 in each year, that of the plot in which this ingredient was included becomes 186, 122, 120, 149 and 109 in the five years commencing 1930. As indicated above, it is not considered that the figures for 1934 do justice to the wild white clover plot, since it was inadequately stocked in the latter half of the season. Over the five grazing seasons, the inclusion of wild white clover has resulted in an average gain of 97 lb. live weight increase per acre per annum, or, if the average yield of the no wild white clover plot is put at 100, that of the other is 125. This increase of 25 per cent. has been obtained under conditions favouring the establishment of indigenous wild white clover when none of this ingredient is included in the seeds mixture; furthermore, it has been obtained under conditions of high productivity, as will be observed from the live weight gains from an acre.

The superiority of the wild white clover plot has been mainly

due to its greater stock carrying capacity. The individual animals did slightly better on that plot, but the difference in the average gain per head of stock was small, and, on some occasions, there was none. The greater stock carrying capacity of the plot in which wild white clover had been sown was evident each year, and was greater in 1934 than at any time since seeding down. While the number of cattle was the same on both plots, there were five ewes and five lambs to the acre on the one plot, and four ewes with four lambs on the other; the proportion of wether lambs was six to four.

In some years the ewes and cattle on the wild white clover plot have shown a greater tendency to scouring than those on the other. In addition, in 1934 Dr. Maldwyn Davies observed that the wether lambs on the wild white clover plot were more prone to maggots than the others—there were more cases of "fly blow" which had failed to take, even on parts of the fleece, such as on the shoulder, which were far enough not to be affected by scouring.

Conclusions.

1. An old pasture has been compared with a pasture laid down in 1927. During the four grazing seasons commencing 1931, the temporary pasture has given 40 per cent. more live weight increase than the permanent grass.

2. The old pasture fails to support lambs in a thriving condition after August; such a condition is sometimes described as "sheep-sick." As part of an attempt to find whether this condition is due to worms, or to mineral deficiency, half of the old pasture was given a dressing of mineral manures early in 1934. Further grazing must take place before conclusions can be drawn.

3. Two temporary pastures have been compared. In one of these, 1 lb. of wild white clover was included when seeding down in 1927, but this ingredient was omitted from the other. Over five grazing seasons, commencing 1930, the plot in which white clover was sown has given 25 per cent. more live weight increase than that from which it was omitted.

4. The superior live weight increase from the wild white clover plot was mainly due to a greater stock carrying capacity.

A PRELIMINARY REPORT ON THE WORK OF THE CAHN HILL IMPROVEMENT SCHEME.

By MOSES GRIFFITH, M.Sc., Lands Director,
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The work of the Cahn Hill Improvement Scheme was started in 1933 immediately following upon the occupation of the necessary lands. After exploring a number of possibilities it was finally decided to enter upon possession of a block of hill land on the Hafod Estate near Devil's Bridge, and fifteen miles from Aberystwyth. These lands constitute the main area taken over by the scheme, and it is here that the headquarters have been established. The area in question falls into three well defined units, namely :—

1. Pwllpeiran, one of the home farms, consisting of eighty-eight acres of fields, 195 acres of hill grazings, and seventy-eight acres of woodlands.

2. Prignant and Banc y Bont, consisting of fifteen acres of fields, 312 acres of hill grazings and 17.5 acres of woodlands.

3. Nant Rhys, a sheep walk of 2,200 acres.

In addition, and with a view to conducting trials over a wide range of conditions, two blocks of land with an aggregate area of 120 acres were leased on the Whitton Hill near Knighton, Radnorshire. Seven acres of land at Ponterwyd, previously leased by the Welsh Plant Breeding Station for experimental purposes, were also taken over by the scheme. Possession was taken of Pwllpeiran on Lady Day, 1933, and of the remaining lands at Michaelmas of that year (1).

The Pwllpeiran and Prignant hills range from about 1,000 to 1,350 feet above sea level. They carried a herbage of very inferior quality, comprising *Nardus* and sheep's fescue, with a small percentage of bent on the drier slopes, with *Molinia* on the wetter slopes and *Molinia* and rushes on the flat portions. Nant Rhys is a very exposed and open sheep walk, ranging in elevation from 1,500 to 1,850 feet. The greater part of the area is composed of *Molinia* and *Nardus* with *Scirpus*; there are considerable areas of pure *Molinia*, and on a few of the drier slopes small areas of sheep's fescue with *Nardus* are interspersed.

The first operation to be carried out was a systematic burn-

ing of the Pwllpeiran Hill during the latter part of March, 1933, and we were extremely fortunate in having exceptionally good weather for this—as a matter of fact we were able to burn the marsh portion twice over. The next operation was cultivation, and it was decided to cultivate the major portion of the land with the Austral Rotary Cultivator which is used for most of the reclamation work on the Continent. It has, however, one disadvantage as compared with the Lanz in that the knives are larger and further apart, with the result that it cuts pieces of turf which are larger and consequently more difficult to deal with. About fifteen acres of the Pwllpeiran hill were cultivated with the Austral and another ten acres with a Pitchpole harrow, behind which was attached a New Zealand Whakatane harrow. In order to obtain even a fair tilth with these two harrows it was necessary to cover the ground four times, whereas the Austral did the work at one operation. This is a very important factor, as every extra operation increases the cost. In both types of cultivation a large amount of roughage comprising the old matt herbage and roots was torn out, and the problem then was to find an implement to deal with it. A chain-harrow, a hay-rake, a side-rake, and various other implements were tried, but with very little success. The best results were obtained with the side-rake. Eventually a road sweeping brush was tried and proved very successful, collecting the clods and the roughage into small windrows which were left to dry and then burnt.

After having been burnt the land was manured by means of a horse-drawn manure distributor with 6 cwt. basic slag and 1 cwt. nitro-chalk per acre. The area was then sown down with a mixture consisting of Yorkshire fog and cleanings of wild white clover and indigenous rye-grass, and harrowed. The weather during June and July of 1933 was dry and hot, consequently germination was comparatively slow.

Soon after possession had been taken of the land, a programme of fencing was drawn up and let out on contract, and, by the time of sowing, the cultivated block was fenced round. The stock was then moved to graze on the rest of the hill. All the animals showed a marked partiality for the young *Molinia* on the burnt portion of the marsh; these spots were so persistently grazed that the *Molinia* was greatly reduced by the following year.

In addition to the foregoing five acres, a portion of wet marsh was cultivated with the Austral cultivator, but owing to the wet nature of the land it was impossible to use any implement to collect the clods together. Consequently the greater part

of this area was manured and rolled, and seed was sown on the rough surface. In order, however, to give this type of land a fair test, a small area of one-and-a-half acres was cleared by manual labour, the clods being collected into heaps with forks and then burnt. The land was then manured and sown, and it was on this plot that the best take of all was obtained in 1988, when a thick sward of grasses and clovers was produced, alsike and wild white clover deserving particular mention. The other portion of the Australed bog was simply rolled, manured and sown with Yorkshire fog, and on this part there was a highly successful take.

In addition to the above, and after all the cultivated land had been sown, a block of seven acres was marked out to be ploughed on the hill. We first tried an old Oliver plough, but this soon became bent and could not be used. A Ransome's three-furrow Midtrac plough was bought, and by the time this block was finished, this plough was also badly bent. After consultation with the manufacturers, it was decided to try Messrs. Ransome's Junotrac two-furrow plough, and with this plough we have ploughed over 100 acres of very rough and rocky land without a breakdown, apart from breaking an occasional share or disc. The possession of such an instrument enabled us to cultivate and grow rape and turnips for fattening on convenient blocks at Pwllpeiran and Prignant. These areas have now been fenced off and can be used to grow fattening crops for a number of years withough re-ploughing, simply by discing and harrowing in the seed; or for sowing with permanent seeds and making into intakes.

The lowland fields at Pwllpeiran totalled eighty-eight acres, of which seventeen were under the plough. The quality of the herbage was poor with a very high percentage of bent and Yorkshire fog and very little wild white clover. It was realised that the holding as then constituted would provide winter keep for only a very limited number of sheep. Therefore part of a twelve acre field, of which half had been under roots, was cultivated and sown down with drills of Timothy grass. The results obtained from this crop, and from another field sown with pure Italian rye-grass, are dealt with in another article in this *Journal.* It is intended to plough up a fresh field each year and sow it down with a good permanent seeds mixture.

During the spring of 1934 fifty-five acres of the Knighton land were ploughed up, cultivated, and sown down the following May with a permanent mixture, twenty-five acres of these

fifty-five were also sown with rape and turnips as a nurse crop. At Pwllpeiran and Prignant eighty acres were ploughed, manured and sown down. Of these eighty acres, approximately forty-four were sown with rape and turnips and a temporary seeds mixture, fourteen with rape and turnips with a permanent seeds mixture, and the remainder with permanent mixtures. In addition thirty acres were scratched up with a rotary cultivator, manured and sown with seed cleanings. Five acres were manured and sown only and a block of four acres at Prignant received manures alone. All these operations were carried out with a caterpillar tractor except on one block of seven acres. This field consisted of very steep bracken-infested slopes and was chosen as a demonstration area on which all operations were to be carried out by horse labour. Most of the steeper slopes were ploughed one way with a double furrow plough and three horses.

In the improvement of hill land it is necessary to employ a high seed rate per acre. The seeds mixture consisted mostly of wild white clover and indigenous rye-grass cleanings, both of which contain a considerable proportion of crested dogstail, to which was added some cocksfoot and Yorkshire fog. Though Yorkshire fog is regarded as a weed, its use on poor hill land has given excellent results, especially on boggy land and on areas of very low fertility. The average rate of sowing was 90 lb. to the acre; some of the seed was harvested in 1931 and 1932. The manuring rate, except on experimental plots, was 6 cwt. 32 per cent. basic slag and 1 cwt. nitro-chalk per acre. Owing to the extremely dry weather the take was generally extremely poor, and most of the seed was shrivelled up within a few days of germination. In addition the turnip flea beetle played havoc with the rape and turnips, the former being almost entirely destroyed. The drought broke towards the end of July and the newly-sown areas came on remarkably well, considering the adverse conditions which prevailed after sowing. There was a fair take of grass and clovers, and on the better portions about half a normal crop of turnips.

A large number of implements have been tried out on the hill with varying success. Space does not permit of an account of them being given here, but it may be mentioned that one, the Fishleigh Rotary Cultivator, seems very promising, a small area cultivated with this machine during 1934 having given very good results.

There was no obligation to take over any stock at Pwllpeiran, but 150 couples of the original sheep stock were bought in May,

1933. These were grazed on the burnt unimproved hill at Pwllpeiran to start with and finished on the new pastures. At Michaelmas, 1933, possession was taken of Prignant and Nant Rhys, and the sheep stock of both had to be taken over at an agreed price. About half the ewes and all the lambs from Prignant were culled and sold immediately, and the remainder of the flock was kept for one year to settle the new sheep. At present the whole Prignant flock consists of about 240 ewes purchased in 1933 and 1934 from eight well known North Wales flocks, most of which have been bred on the mountain from hardy pedigree rams; none of the original sheep are now left. At Nant Rhys a total of 1,340 sheep (ewes and wethers), and 400 mixed lambs had to be taken over. This sheep walk is unfenced on two sides and when we took it over did not possess one single sheep-proof enclosure on the whole 2,200 acres. Therefore the problem of the improvement of the Nant Rhys flock was a very different one from that of the Prignant flock, where the whole hill was totally enclosed. So far as is known the Nant Rhys flock was originally of the Welsh Mountain type, characteristic of the district. In the latter half of the nineteenth century, Scotch Blackface and Cheviot rams were introduced, until a change of ownership brought about a reversion to the use of Welsh Mountain rams, the new owner endeavouring to work out the Blackface blood. However, one of the bailiffs introduced a number of Herdwick rams and these and their progeny were used almost exclusively until 1900 when a change in agents again caused a return to the use of Welsh Mountain rams. This process was accelerated during the years 1905-1914, when a policy of drafting out all the crossbred rams was in operation. All the succeeding agents and tenants continued the use of Welsh Mountain rams except the last one, who introduced a number of dark-faced rams, locally called "Penllwyd Mynydd." Consequently the flock as taken over by the scheme was of a very mixed character. as regards type, fleece characteristics and face colour. On account of the bad fencing it would have been unwise to buy new rams in 1933; therefore it was decided to use the rams bought with the flock. By 1934, however, three fairly large paddocks had been made at Nant Rhys and a number of new rams were bought and used. Nant Rhys is a very exposed and high sheep walk, eight miles from the nearest village, and all the older ewes had to be hardy enough to live on the mountain throughout the year, and to rear their lambs there. Now the problem was to find suitable rams to use to improve the flock. Local opinion—of very shrewd mountain farmers at that—is very much against

the use of pedigree rams because it is thought that their progeny are not hardy enough to stand the winter on the mountains. The course adopted, therefore, was to keep about twenty of the best of the rams taken over with the flock, and to use them on the outskirts of the sheep walk as far as possible. In addition about twenty new rams were bought, selected from the best flocks in the surrounding district. Also three pedigree rams were used in one paddock and the ewes marked.

During the summer and autumn of 1933 the nucleus of a small herd of pedigree Welsh Black cattle was bought, and one of the best bulls in the breed, "Egryn Buddugol," was hired for two years. A number of calves from Welsh Black cows and heifers were successfully reared on the improved pastures during the summer and sold as veal in August and September. A number of yearling heifers was grazed on the improved hill pastures during the summer and made good progress.

With the exception of one half-legged mare, all the horses used on the farms are Welsh cobs. It has been found that this breed is the cheapest to keep and is the most active and hardy on the steep hill slopes. During the autumn of 1933 a small draft of mountain pony mares was bought from the Bangor College farm. These were served by a Welsh Mountain pony stallion, but next season it is intended to use a half thoroughbred colt in order to breed riding ponies.

The foregoing will give the reader some idea of some of the work that has been done in the course of the establishment of the Cahn Hill Improvement Scheme, but it is as yet too soon to say much about the results.

It may, however, be of interest to give some of the grazing results obtained from the first block of hill land that was cultivated and sown in April and May, 1933. This area has a total acreage of 31.5 acres of which twenty-five acres are improved. The Pwllpeiran hill, before it was taken over by the Cahn Hill Improvement Scheme, was only capable of carrying one ewe and one lamb per acre during the summer months. It carried no stock in winter. During the summer of 1933, the hill carried 150 ewes and their lambs; these grazed most of their time on the burnt marsh until they were turned on the new pastures in August. The new pastures were rested from the middle of September until the end of October, when fifteen cattle were turned on them. Five of these, the Shorthorns, had to be put indoors about the middle of November, the Herefords and Welsh Blacks remaining on the hill until the snowstorm of December 3. The land was then rested until January 22, when seventy Nant Rhys

ewes were turned in, remaining until after lambing time in April. Early in May, 1934, the pastures were stocked with 128 couples and these grazed all through the summer until the end of August, when the lambs were weaned and turned on the rape and turnips to be finished for the butcher. The average weight of these lambs when weaned was 47 lb., and if we take the weight of a normal Welsh Mountain lamb at birth as being 6 lb., we get a live weight increase of 41 lb. per lamb, which is equivalent to 167 lb. live weight increase per acre. This area during the winter of 1933 gave 465 cattle days (one cattle day = seven sheep days), which is equivalent to 3,255 sheep days, and also sheep grazing for 6,370 days. This means that the area carried the equivalent of fifty-four ewes during the winter months, whereas previously it carried none at all. Its summer carrying capacity increased from one ewe and one lamb per acre to approximately four ewes and four lambs per acre.

The following chemical analysis is included in order to give some idea of the difference in quality and nutritive value of the old and the new pasture.

	Improved pasture.	*Adjoining Unimproved pasture.*
Moisture	83.06%	46.45%
	Based on	*Dry Matter.*
	%	%
Ether Extract	3.41	2.85
Crude Protein	18.9	7.08
True Protein	12.42	6.21
Fibre	19.56	31.97
Ash	10.61	8.16
Soluble Carbohydrates ...	47.52	54.94
Phosphoric Acid (P_2O_5)	0.85	0.16
Lime (CaO)	0.55	0.20

As has been previously stated, a considerable acreage of newly ploughed hill land was cropped with rape and turnips, with which was sown a permanent or a temporary seeds mixture. If an average were taken of the lambs fattened per acre on these pastures at Pwllpeiran and Prignant, the figure would be approximately eight lambs per acre; or, if one area, which suffered even more severely than the others from the drought, be excluded, the figure would be approximately twelve lambs per acre. On the other hand one area of seven acres fattened over fifteen lambs

per acre and gave a live-weight increase of over 94 lb. per acre. During the autumn and early winter of 1934, over 650 lambs were sold fat from the new pastures, and in addition over 200 fat sheep, making a total of more than 850 sheep fattened on temporary crops grown on poor hill land at an elevation ranging from 850 to 1,350 feet.

Acknowledgements.

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Thanks are also due to Professor T. W. Fagan, M.A., for carrying out the chemical analysis.

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FIELD TRIALS WITH PEDIGREE AND INDIGENOUS STRAINS OF GRASSES.

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Work on the production of pedigree strains of grasses has now been in progress at the Welsh Plant Breeding Station for several years. Ever since small quantities of seed have been available trials have been conducted on fields covering a wide range of soil and climatic conditions in Wales.

The purpose of this paper is to point out the advantages of pedigree and good indigenous strains of grasses compared with ordinary commercial strains in simple mixtures under the usual systems of management on Welsh farms. The management throughout has been completely in the hands of the farmer. Three series of trials are discussed; small plots sown in 1928 (E.86) and in 1929 (E.97) and large demonstration areas sown in 1931 (E.140).

At each centre the pedigree or indigenous mixture has been superior to the farmer's mixture in the same field, and in the 1928 and 1929 trials the figures represent an average for each type of plot mixture tested. A direct comparison is made with the farmer's mixture on an adjacent area in the same field. The

figures, as an average of a number of centres where similar mixtures were sown, should be highly significant. The compounding of the mixtures was based on evidence from previous trials.

Unfortunately, on account of scarcity of seed, no selected rye-grass strains developed at the Welsh Plant Breeding Station were included in these trials. The data in relation to perennial rye-grass, therefore, refer to the indigenous strains on the market.

THE 1928 TRIALS (E.86).

Material and Methods.

In the spring of 1928 a one-tenth acre strip was sown in the same field as the farmer's mixture at several centres in each of the following counties : Brecon and Radnor, Cardigan, Carmarthen, Caernarvon, Merioneth, Montgomery and Pembroke. Each field was seeded down under a cereal nurse crop. At most centres hay was taken during the first three harvest years, and at one or two centres even in the fourth year.

Detailed analyses of the plots were made in the summer of 1932, the fourth harvest year, and a similar sized adjacent area of the farmer's mixture was analysed at the same time at each centre. All the analyses were carried out by the percentage tiller estimation method (1).

TABLE I.

Details of the plot mixtures; sown 1928.

Species and strain.	*Mixtures in lb. per acre.*		
	I.	*II.*	*III.*
Italian rye-grass	6	6	6
Perennial rye-grass (indigenous)	14	—	14
Cocksfoot (pedigree) ...	—	16	—
Rough-stalked meadow grass ...	4	4	4
Crested dogstail	4	4	—
Montgomery late-flowering red clover	4	4	4
English wild white clover	3	3	3

The Mixtures.

Particulars of the seeds mixtures used are given in Table I. Mixtures I and III were designed for more fertile conditions suited to perennial rye-grass, while Mixture II, containing

cocksfoot as the dominant grass, was intended for poorer conditions.

The farmer's mixture as a rule contained broad red clover and perhaps late-flowering clover, with Dutch white rather than wild white clover.

TABLE II.

The percentage contribution of sown grasses, clovers and weeds in the fourth harvest year (1932) for each of the mixtures tested.

Mixtures.	*Sown grasses.*	*Red clover.*	*White clover.*	*Unsown grasses.*	*Miscellaneous weeds.*
Mixture I	57.8	0.4	7.8	29.3	4.7
Farmer's Mixure	39.8	0.1	5.2	18.5	6.4
Mixture II ...	70.4	0.1	9.4	14.0	6.1
Farmer's Mixure ...	46.5	0.3	10.1	32.2	10.9
Mixture III	67.3	0.2	10.8	16.9	4.8
Farmer's Mixture	44.0	0.1	6.8	40.2	8.7

Discussion of Results.

A report on the behaviour of the plots in the second harvest year has already been published (2). It is not necessary, therefore, to reiterate the details in this article.

The figures in Table II were taken during the summer of the fourth harvest year, 1932, and represent the contribution of the various constituents under pasture conditions; the superiority of the plot mixtures compared with the farmer's mixture is well shown. Many of the farmers did not include wild white clover in their mixtures, but by the fourth harvest year it had made a significant unsown appearance. Its late coming-in, however, did not prevent the entry of an undue amount of unsown grasses and miscellaneous weeds—a very marked feature of the farmer's mixture compared with the indigenous plots. The high figure for sown grasses in Mixture II is accounted for by the persistency and high tillering capacity of pedigree cocksfoot. The bottom grasses, rough-stalked meadow grass and crested dogstail, species generally not included by the farmer in his mixture, have helped to keep out unsown grasses from the indigenous plots. Even the best strains of red clover do not persist to any extent into the fourth harvest year, the figures as such are of no practical value.

THE 1929 TRIALS (E.97).

Material and Methods.

These trials were laid down in the spring of 1929 in the same counties as the 1928 trials, and again under a cereal nurse crop. Hay was taken at most centres during the three years under review. Two one-tenth acre trial plots were sown at each centre. Pasture analyses were carried out in the summer of 1932, using the same method as for the 1928 trials. Counts of cocksfoot and rye-grass tillers were also made on all the plots. Ten readings per plot were taken, using a square mesh 6in. × 6in. (inside measurements) for the readings (1). A similar sized area of the farmer's mixture was also analysed at each centre.

The Mixtures.

Particulars of the mixtures used are given in Table III. Two trial mixtures were tested, one cocksfoot-dominant and mainly for uplands; the other for second-class lowland conditions. In order that a direct comparison could be made between pedigree and commercial cocksfoot, two plots were sown at each centre; they were similar in all other respects, but one contained pedigree and the other commercial cocksfoot at the same rates per acre.

TABLE III.
Details of the plot mixtures; sown 1929.

Species and strain.	*Mixtures in lb. per acre.*			
	Ia	*Ib*	*IIa*	*IIb*
Italian rye-grass ...	6	6	6	6
Perennial rye-grass (indigenous)	—	—	9	9
Cocksfoot (pedigree) ...	16	—	9	—
Cocksfoot (Danish) ...	—	16	—	9
Rough-stalked meadow grass ...	4	4	4	4
Crested dogstail ...	4	4	—	—
Montgomery late-flowering red clover	4	4	4	4
English wild white clover	3	3	3	3

Discussion of Results.

The figures in Table IV show comparisons of the two mixtures under consideration, one with the other as well as with the farmer's mixture sown on the general body of the field. As a rule farmers sow only a very small amount of cocksfoot in their

mixtures, and the dominant ingredient is almost always rye-grass. Commercial cocksfoot, however, either at a high rate of seeding or at a low rate does not persist well when grazed hard in the spring as the third harvest year figures show. On second-class soils, and in the third harvest year, pedigree cocksfoot is an aggressor relative to rye-grass. This is particularly the case where a series of hay crops, often cut too late, has been taken. Cocksfoot is benefited by being put up to hay, whereas perennial rye-grass is favoured correspondingly by well managed pasture conditions. Where, however, the hay crop is cut early and is not too heavy, indigenous strains of rye-grass are found to be quite persistent, even on these second-class soils.

TABLE IV.

Showing (a) the percentage contribution of sown grasses, clovers and weeds, and (b) actual counts of rye-grass and cocksfoot tillers per 2½ sq. ft. in the third harvest year (1932).

Mixtures.	*Percentage tiller estimation.*				
	Sown grasses.	*Red clover.*	*Wild white clover.*	*Unsown grasses.*	*Miscellaneous weeds.*
Mixture Ia	65.8	0.4	9.4	18.7	5.7
,, Ib	63.2	0.8	11.3	17.6	7.1
Farmer's Mixture	50.5	0.8	6.3	33.9	8.5
Mixture IIa	74.7	0.7	9.3	11.9	3.4
,, IIb	70.4	0.8	11.1	13.2	4.5
Farmer's Mixture	61.3	0.6	6.7	26.0	5.4

Mixtures.	*Counts of tillers per 2½ sq. feet.*	
	Rye grass.	*Cocksfoot.*
Mixture Ia	40.2*	260.0
,, Ib	61.7*	85.2
Farmer's Mixture	125.6	58.9
Mixture IIa	194.9	245.6
,, IIb ...	285.0	68.8
Farmer's Mixture	138.6	65.5

* Unsown, including rye-grass "sown" at hay harvest—seed scattered in haymaking.

The number of tillers of indigenous perennial rye-grass per unit area in Mixture II*b* is much higher where it is in competition

with the non-persistent, poor tillering commercial cocksfoot. It is significant that indigenous perennial rye-grass competing with pedigree cocksfoot shows more tillers per unit area than the ordinary commercial strain of the farmer's mixture, even when this latter strain is only in competition with a light seeding of commercial cocksfoot.

Added significance is given to the pedigree cocksfoot in these figures, because in contrast to perennial rye-grass it generally makes but little unsown appearance on Welsh soils.

There is only a very slight difference between the percentage contribution of wild white clover on the two trial plots, in spite of the aggressive nature of pedigree cocksfoot at this stage in the formation of the sward.

An important feature is the value of the bottom grasses and wild white clover as suppressors of unsown grasses as shown in Mixtures I*b* and II*b* when compared with the farmer's mixture. When Mixtures I*b* and II*b* (commercial cocksfoot), however, are compared with Mixtures I*a* and II*a* (pedigree cocksfoot), on the basis of production, they are very inferior, since commercial cocksfoot is dying back very rapidly. Pedigree cocksfoot under these conditions is very productive in the third harvest year. It has the further advantage that it is very leafy and compared with commercial cocksfoot does not become so badly winter-burned.

THE 1931 TRIALS (E.140).

As the supplies of pedigree seed increased it was possible to carry out large scale trials. Accordingly, in 1931, large demonstration areas were laid down at two to six centres in each of the Welsh counties. The plots varied in size from one to four acres, but at most centres they were three acres. In order to have a fairly distinct comparison a strip one-fourth acre in size, and containing similar seed rates of commercial strains, was sown separately on the same field as the main indigenous block at all centres. At a few centres wild white clover was used for both the commercial strip and the indigenous block, but at most centres the commercial mixture contained Dutch white as opposed to wild white clover. On the commercial strip, Chewing's fescue replaced red fescue, and a mixture of late-flowering red clover and broad red clover replaced Montgomery red clover. Dogstail and alsike when included in the indigenous mixture were also used in the commercial mixture. A few of the centres were analysed in the summer of the first harvest year. Almost

all the centres were visited during the autumn of the third harvest year, 1934.

On account of lack of time it was not possible to analyse the plots botanically, but detailed notes were made. Hay had been taken at most of the centres during the three harvest years. As in the 1928 and 1929 trials a cereal crop was used as nurse.

The Mixtures.

Particulars of the mixtures used are given in Table V. They were designed for specific conditions as far as possible; Mixture I for thin-soiled uplands; Mixtures II and III for second-class lowlands and Mixture IV for heavy or peaty soils.

TABLE V.

Details of the seeding per acre of the plot mixtures, sown 1931.

Species and strain.	*Mixtures in lb. per acre.*			
	I	*II*	*III*	*IV*
Italian rye-grass ...	4	4	4	4
Perennial rye-grass (indigenous) ...	—	8	—	—
Cocksfoot (pedigree)	16	10	10	6
Timothy (pedigree)	4	1	10	12
Red fescue (pedigree)	—	4	—	6
Crested dogstail ..	1	—	4	—
Montgomery late-flowering red clover	1	1	4	—
Wild white clover	2	2	2	2
Alsike	—	—	—	1

Discussion of Results.

First Harvest Year (1932). It was not possible to visit all the centres, but the general trend of the data collected was as follows.

Perennial rye-grass. Under grazing conditions the indigenous strain did exceptionally well and was far superior to the commercial strain. Under hay conditions it was highly productive and a little superior to the commercial strain.

Cocksfoot. The pedigree strain was distinctly superior to the commercial strain under grazing conditions, but as hay the advantage was in favour of the commercial strain.

Timothy. No marked difference was evident between the strains, but neither strain was contributing to the herbage to any appreciable extent.

Fine-leaved fescues. Under grazing conditions red fescue

was superior to Chewing's fescue. As hay neither strain made any significant contribution.

Red clover. The superiority of Montgomery over late-flowering and broad red was very pronounced, particularly under pasture conditions.

White clover. Both wild white and Dutch white clovers did better under pasture conditions than as hay. The adverse effect of hay, however, was more marked in the case of Dutch white clover.

Third Harvest Year (1934). Almost all the centres were visited in the autumn of the third harvest year. Consultations with the farmers and their keen desire for more seed or similar prescriptions indicated very strongly how much better these indigenous plots were in their view than either their own mixture or the commercial strip. The mixtures were primarily intended as grazing trials, but at most of the centres hay had been taken each year. The farmers were loud in their praise of the plots and were unanimous in their belief that even as hay producers the plot mixtures were far more productive than the commercial strip. This was due in the main to indigenous rye-grass and pedigree cocksfoot. Danish cocksfoot in particular lacked persistency with the result that bent and Yorkshire fog were gaining ground very rapidly. Pedigree cocksfoot is very productive in the second and third harvest years, and although the strain used in these trials was more or less of the pasture type it is capable of producing a fair crop of hay for several years. This feature has been brought out rather well in other older trials.

At the time of visiting, the Danish cocksfoot was showing signs of winter-burn, while pedigree cocksfoot was making a dense stand at all centres and was quite green.

Perennial rye-grass in Mixture II, both on the indigenous block and on the commercial strip was contributing well, but the indigenous strain was more leafy.

In Mixtures I and II the strains of timothy were sown at only 4 lb. per acre, and contributed but little to the herbage. At 10 and 12 lb. per acre in Mixtures III and IV respectively, the indigenous strain especially did much better, but was not so productive in aftermath as cocksfoot.

Chewing's fescue was badly burned on all the strips where it was sown, and for this reason the plots were somewhat out of hand. Red fescue blended well with the general mixture and was very useful as a weed suppressor without occupying a dominant position, a feature so common with the fine-leaved fescues when well established. Judging by the grazing of the plots as a whole,

it would not appear to be unpalatable in a mixture. It showed no sign of winter-burn.

Dogstail showed to advantage, but at some centres the prevalence of unpalatable wiry stems showed the need of the mowing machine over these pastures. Red clover had almost disappeared from the commercial strips and was very thin on the indigenous plots. Alsike plants were difficult to find. There was a fair contribution of wild white clover on all the plots.

The commercial plots at many centres were showing very clear signs of reversion by the ingress of bent and Yorkshire fog.

General Conclusions.

In the trials under review, scattered as they were throughout the various Welsh counties, the general evidence seems definitely to confirm all previous evidence obtained from critical trials. Simple mixtures containing pedigree or indigenous strains of grasses with wild white clover are far superior for sward formation and persistency to ordinary commercial strains (3).

At most centres the farmers had included alsike, trefoil and meadow fescue in their mixtures. Analyses of these mixtures in the second harvest year indicated that alsike and trefoil made very meagre contribution to the herbage. The third harvest year analyses showed the presence of extremely little meadow fescue. On most Welsh soils these three species can, with advantage, be omitted from mixtures for permanent grass and reliance placed on a more knowledgeable use of species which are known to do well.

On the poorer soils, and particularly on uplands where spring grazing is severe, pedigree cocksfoot is particularly valuable. Ordinary cocksfoot, since it tillers so badly, is not able to withstand hard grazing conditions. Cocksfoot, however, compared with perennial rye-grass is slow to establish itself from seed, and contributes but little to the first hay crop. For this reason perennial rye-grass should always be included in the mixtures. In the second year indigenous perennial rye-grass is far more productive than the commercial strains. In subsequent years pedigree cocksfoot, under both hay and pasture conditions on thin, dry soils of low fertility, is more productive than perennial rye-grass. Pasture strains of perennial rye-grass, however, are very useful for sward formation, even under conditions of low fertility. On moist lowland soils of high fertility it is probable that pedigree or a good indigenous strain of perennial rye-grass is the only top grass needed, because under good management it

can persist in a vigorous state of productivity for a number of years.

Commercial timothy generally is not a valuable inclusion in permanent mixtures. The indigenous and pedigree strains to be successful must be sown at a fairly heavy seed rate. As a rule they do best on heavy and peaty soils. Generally farmers' mixtures do not contain bottom grasses such as crested dogstail, rough-stalked meadow grass and red fescue. Their necessity for sward formation and weed suppression is important.

Rough-stalked meadow grass does well on the lowlands, provided the soil is fertile and not liable to suffer from drought.

Crested dogstail is useful on a variety of soils. It has an added advantage on thin, dry soils because it contributes fairly well to the second and third hay crops. On soils of low fertility pedigree red fescue, at a light seed rate of 2 lb. per acre, is a valuable inclusion. Its commercial counterpart, Chewing's fescue, becomes very winter-burned and unpalatable.

The absence of wild white clover from most commercial mixtures is a matter that demands the farmer's urgent attention, since it should be the most important constituent in all mixtures for permanent grass. It is true that after three years on many soils white clover may make its unsown appearance in appreciable quantities, but by this time weeds have occupied too large a percentage of ground space for successful sward formation. Pastures containing a fair proportion of wild white clover have a high feeding value (4, 5). Montgomery red clover is more productive than any other red clover, and vastly superior to alsike both for hay and grazing (6).

Italian rye-grass is valuable for spring and autumn grazing in the first year, and the amount to include depends on the intensity of spring grazing. On upland soils where spring grazing is very severe, and where fields are not closed for hay until early May, 8 to 12 lb. per acre can be used with safety. On lowlands, under ordinary management, 4 lb. per acre is ample.

The conclusions drawn from the evidence apply, in the main, to Welsh conditions, but data from other experiments indicate that large areas of Britain put down to permanent grass are better adapted to the mixture types containing pedigree and indigenous strains discussed in this paper than to the commercial strains generally used.

Summary.

1. Field trials with pedigree and indigenous strains of grasses have been discussed.

2. Pedigree and indigenous strains are more persistent, more leafy, graze better and produce more hay over a period of years than commercial strains.

3. On second-class soils, and especially on thin soils in upland districts, pedigree cocksfoot is more aggressive than indigenous perennial rye-grass in the third year.

4. On lowland soils of high fertility a good indigenous strain of perennial rye-grass is the only top grass needed.

5. Pedigree red fescue blends better than Chewing's fescue in mixtures, mainly because it remains winter-green.

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SEED PRODUCTION IN COCKSFOOT: DENSITY OF SPACING IN RELATION TO YIELD.

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An experiment was laid down in 1932 to study the effect on seminal reproduction of growing cocksfoot plants at various distances apart. Strong seedlings of a leafy cocksfoot (S.128) were transplanted into the field on July 2, and seeds of the same cocksfoot strain were sown in corresponding plots on the same day.

The soil in this particular instance had been fallowed during the previous year, but its quality, partly on account of its shallowness, was not ideally suited for seed production. The area, however, was chosen for its good isolation for multiplying the seed of this new strain.

Three spacings, six, twelve and eighteen inches respectively, were adopted for the seedlings in the rows which were two feet apart. The seed of this strain was very limited, and only sufficient was available to sow the two ft. drills at the rate of 2 lb. per acre. This seed rate provided four seeds per linear inch. It should be noted here that owing to difference in age the drilled seedlings started at a disadvantage as compared with those which were transplanted, and the comparisons to be made involve this factor as well as that of spacing. This might be expected to affect the yields in the first harvest year to a greater extent than those of the second.

Each plot covered 1/120th acre, and the four treatments were replicated six times at random within the six randomized blocks. A timothy clone planted at the end of every plot row served to demarcate the plots.

Management.

Satisfactory establishment was obtained, both with seedlings and seeds, although the conditions for growth were rather dry for some time after planting. An initial application of mineral fertilizers was given in early April of the first harvest year at the rate of 44 lb. P_2O_5 (superphosphate) and 48 lb. K_2O (sulphate of potash), together with 81 lb. N. (nitro-chalk) per acre.

The dry situation of the experiment and the exceptionally

rainless first harvest year, followed by a dry spring in the second harvest year, seemed to warrant heavier applications of nitrogen for the second seed crop, hence, 23.75 lb. N. per acre were applied in September of 1933, and 46.5 lb. N. per acre in early April, 1934.

A rototiller was used chiefly for inter-drill cultivations, but this implement had to be supported by hand-hoeing in the early stages, and more especially on the plots established from seed.

Results.

Marked differences appeared by the first autumn between the plots treated differentially, and the greatest contrast existed between the plants spaced at 18 inches and those established from seed sown in the drills. The former had developed a robust growth, and a deep green colour, whilst the latter were a light green colour and rather weak. These differences were maintained until the first harvest, but not in the same degree as in the planting year.

All the plots reached maturity about the same time, and were harvested on the same day. Before harvesting was begun ten quadrat samples, each 18 inches long, were taken at random from each of the 36 plots for making tiller counts. The seed crops were conditioned in stooks on the field and carried indoors in canvas sheets when thoroughly dry. No two consecutive seasons could have provided better harvesting conditions than the summers of 1933 and 1934, and thus the crops could remain safely in their wrappings until they could be weighed and threshed during the winter months.

1933 Crops.

It is convenient to analyse the data derived from the 1933 seed crops separately from those of the second seed crop in 1934. Table I shows the various data collected from the first seed crop.

(*a*) *Gross Yield.* The gross dry weight per acre will be seen from the table to be significantly lower in both sown plots and plots established with plants spaced at 18 inches than under the other two treatments. It is very probable that had the seed been sown in early spring the yield from the sown plots would have been appreciably greater. Two factors thus affected the growth of the " sown " plots adversely, namely, the late sowing coupled with an exceptionally dry summer.

(*b*) *Barren Tillers.* The number of barren shoots per unit area seems to be negatively correlated with the spaces at which

the seedlings were planted originally. Plant development was very backward on the sown plots in the seeding year, and the large proportion of tillers produced in the following spring were probably too late to pass into the reproductive phase.

TABLE I.

Showing for the first seed crop of cocksfoot (a) gross yield in cwt. per acre; (b) and (c) barren and fertile tillers per linear foot; (d) yield of seed in lb. per acre, and (e) weight per 1,000 seed under various densities of plant establishment.

1933. First harvest year.	*Seed sown.*	*Plants spaced*			*Mean.*	*S.E.*
		6 in. apart	*12 in. apart*	*18 in. apart*		
(*a*) Gross yield per acre: cwt.	10.3	29.8	32.1	24.6	24.2	1.28
,, ,, per cent. of mean	42.5	123.1	132.8	101.6	100.0	5.31
(*b*) Barren tillers per ft.	44.1	38.5	18.8	15.6	29.2	4.16
,, ,, per cent. of mean	151.0	131.9	64.3	53.4	100.0	14.29
(*c*) Fertile tillers per ft.	7.3	56.7	60.2	51.1	43.9	4.22
,, ,, per cent. of mean	16.6	129.1	136.7	117.0	100.0	9.62
(*d*) Seed per acre: lb.	53.7	411.5	411.3	393.1	318.1	26.40
,, per cent. of mean	16.9	126.2	130.2	123.6	100.0	8.30
(*e*) Weight per 1,000 seed: gm.	0.890	0.821	0.844	0.822	0.845	0.024
,, per cent. of mean ..	105.3	97.5	99.8	97.3	100.0	2.85

It will be observed in Table I that the number of barren tillers in the plants spaced at 6 inches is significantly higher than that representing plants spaced either at 12 inches or 18 inches apart. This difference is probably due to the effect of hoeing between the wider spaced plants in the year of planting, which was not possible between the plants 6 inches apart.

(*c*) *Fertile Tillers.* No significant differences are found in the number of fertile tillers produced per unit area from the planted plots, but the fertile tillers are much fewer in the sown plots. Where the spacing is 12 inches or more between the plants the ratio of fertile tillers to total tillers is greater than under closer spacing. At the same time it will be realized that even though barren tillers are unwelcome in a seed crop, yet they are potentially fertile tillers for a crop in the following year. The aim of the seed grower should be, however, to use every possible means to transform a leafy strain into as stemmy a seed crop as possible. This need not mean that the strain's character is permanently changed by such a technique of seed production.

(*d*) *Yield of Seed.* A comparison of the figures representing the fertile tillers and the seed yields in the table shows that a very close correlation ($r = 0.996 \pm 0.033$) exists between them. As would be expected, therefore, the yield of seed is significantly

lower in the sown plots than in any of the others. This yield of seed from the sown plots which is far below normal, even for a leafy cocksfoot, serves to show the real danger of late sowing, especially if the summer proves to be abnormally dry.

It was observed that no great difference occurred between the number of fertile tillers of the plots planted differentially with seedlings. Table I again shows little difference between the yields of seeds under these three different treatments.

(*e*) *Weight per 1,000 seed.* The figures indicate that although the density of plants under various methods of planting varies considerably the weight of individual seeds is not altered materially.

1934 Seed Crop.

Table II shows that the second seed crop data differ in several respects from those of the first seed crop.

TABLE II.

Showing for the second seed crop of cocksfoot (a) gross yield in cwt. per acre; (b) and (c) barren and fertile tillers per linear ft.; (d) yield of seed in lb. per acre, and (e) weight per 1,000 seeds under various densities of plant establishment.

1934. Second harvest year.	*Seed sown.*	*Plants spaced* 6 in. apart	12 in. apart	18 in. apart	*Mean.*	*S.E.*
(*a*) Gross yield per acre: cwt.	36.2	33.3	33.4	26.1	32.2	1.18
,, ,, per cent. of mean	112.4	103.4	103.7	81.0	100.0	3.68
(*b*) Barren tillers per ft.	86.7	68.4	54.5	63.1	68.5	4.95
,, ,, per cent. of mean	126.5	99.8	79.5	92.1	100.0	7.25
(*c*) Fertile tillers per ft.	38.5	32.8	35.2	32.2	34.4	3.06
,, ,, per cent. of mean	111.9	95.3	102.3	93.6	100.0	8.90
(*d*) Seed per acre: lb.	221.1	227.7	260.9	217.1	231.7	12.32
,, per cent. of mean	95.4	98.3	112.6	93.7	100.0	5.32
(*e*) Weight per 1,000 seed: gm.	0.715	0.709	0.700	0.709	0.708	0.006
,, per cent. of mean	100.9	100.1	98.8	100.1	100.0	0.91

(*a*) *Gross Yield.* The gross yields are higher than those of the first harvest year, particularly on the sown plots. The gross yield from the plots where plants were spaced at 18 inches apart is significantly lower than the yields of all the other treatments, and this result, taken in conjunction with that of the first harvest year, shows that the plants were unable to utilize the extra space for producing maximum yield per unit area.

(*b*) *and* (*c*) *Barren and Fertile Tillers.* On comparing the

tiller statistics for the first and second harvests it will be observed that with the exception of the seed sown plots, the proportion of barren to fertile tillers has been reversed, so that although the total number of tillers is greater in the second crop there are fewer fertile tillers. The extraordinary dryness after the harvest of the first seed crop and the cold weather in the following spring probably account for the paucity of panicles and the failure to produce shoots sufficiently early to enable them to pass into the reproductive phase in the second harvest year. There is also the possibility that the application of nitrogen was on the heavy side, and that this might have encouraged the vegetative phase and tended to suppress the reproductive phase, but neither the total yield nor the increase of total yield over the previous year seems to support the view that the main cause is due to excessive application of nitrogen.

Although barren tiller production is significantly greater in the sown plots than in the other three treatments the differences between the fertile tiller numbers in the four treatments is insignificant.

(d) and (e) Yield and Quality of Seed. The seed yield, under the four treatments, has levelled very considerably in the second harvest year, but the advantage is in favour of plants spaced at 12 inches. It would appear that in circumstances of low expectation the seed yield per acre may be reduced by planting a leafy cocksfoot at more than 12 inches spacing.

A remarkable similarity in size of seed exists between the seed of plots treated differentially as regards density of planting. The variation in weight per 1,000 seed is without any significance, as shown by Table II.

Productivity per Plant.

An altogether different aspect of the result of this experiment is presented by Table III where the influence of density on the productivity of individual plants is shown.

A brief survey of the figures in Table III shows immediately that productivity per plant is correlated positively with the distance between plants. The chief point of interest in this table is the fact that under the conditions of this experiment spacing exerts a greater influence on the reproductive phase than on the vegetative phase. Furthermore, the number of fertile tillers and yield of seed per plant are approximately proportional to the distance between the plants. This increased productivity with

increased space has its limits inevitably, and the figures in Table III show that the percentage increase in productivity tends to diminish when plants are established at intervals wider than 12 inches. Moreover, plants with 12 inches spacing originally

TABLE III.

Showing relative (a) gross yield; (b) number of barren tillers; (c) number of fertile tillers, and (d) yield per plant at different densities of planting.

		Relative productivity per plant spaced		
		6 in. apart.	*12 in. apart.*	*18 in. apart.*
(*a*) *Gross Yield*	1933	100	215	247
	1934	100	200	235
(*b*) *Number of barren tillers*	1933	100	98	121
	1934	100	159	276
(*c*) *Number of fertile tillers* ...	1933	100	212	272
	1934	100	215	295
(*d*) *Seed Yield*	1933	100	201	287
	1934	100	227	286

between them resist the inroads of weeds more successfully than the plants spaced at 18 inches, for they occupy the ground more fully. If, however, there is available only a limited number of plants of a new strain which needs to be multiplied as rapidly as possible, it is obvious from these data that the plants should be given generous spacing in rows.

Counts were not made of plants in the sown plots, but assuming that on the average only one seed out of the four sown per linear inch established a plant, the productivity per plant must compare very unfavourably even with plants spaced at 6 inches apart.

Conclusions.

(1) A comparison of the results obtained shows that cocksfoot plants, spaced at intervals of 12 inches in drills two ft. apart, have yielded more seed per acre than similar plants grown at intervals of 6 or 18 inches, and also than the same strain sown in drills at the time when the spaced seedlings were planted out. It has been pointed out that the latter started at a disadvantage owing to a difference in age, and it is conceivable that if the drills had been sown earlier the difference in yield would have been less pronounced.

(2) If it should occur that the land is not available for seed production until the early summer, and it is vitally essential to

obtain a seed crop of cocksfoot in the following year, then for such circumstances these results indicate that seedlings should be raised and transplanted by early July so that abundant tillers can be formed by the end of September. Such seedlings should be planted at intervals of not less than 12 inches in rows two ft. apart.

(3) The yield of seed is correlated with the number of panicles, and in order to obtain the maximum yield of seed it is essential to have abundant tillers by the autumn so that they may reach the reproductive phase in the following harvest.

(4) Density of planting has no influence on the quality of seed as measured by the weight per thousand seed.

(5) In circumstances where the quantity of seed of a cocksfoot strain is strictly limited, and it is needful to multiply such quantity as rapidly as possible, it has been shown that the best result can be obtained by raising seedlings and planting them in rows with more than 12 inches between each plant.

(6) Increased spacing between cocksfoot plants has greater positive influence on the reproductive phase than on the vegetative phase.

THE EFFICIENCY OF SPATIAL ISOLATION IN MAINTAINING THE PURITY OF RED CLOVER.

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For all practical purposes red clover is almost completely self-sterile, as only about 0.10 to 0.20 per cent. of the flowers set seed as a result of self-pollination. In Britain red clover is cross-pollinated chiefly through the agency of the long-tongued humble bees, which, in return for the food obtained in the form of nectar and pollen, ensure the continuity of the species by transporting pollen from one plant to another.

It is obvious, since all red clover varieties and strains are fully cross-fertile with each other, that an improved strain, situated in close proximity to an unimproved variety flowering about the same time, may become cross-fertilized to an appreci-

able extent by means of bees—much to the detriment of the new strain. As spatial isolation of the crop is the only means that can be employed on a commercial scale of preventing contamination by bee-borne pollen, it is a matter of considerable importance to the seed-grower as well as to the plant-breeder to know precisely how far a strain should be separated from other red clover crops in order to ensure a reasonable degree of purity. The investigations reported in this article were conducted with the object of obtaining information on this point.

It was essential that the strains used for this purpose should be pure for one distinctive recessive character, such as absence of markings on the leaves. The absence of leaf-markings in red clover is a simple recessive character; when plants homozygous for leaf-markings are crossed with plants with no leaf-markings all the resulting offspring have leaf-markings, the presence of this character being completely dominant over its absence. When the offspring of such crosses are mated the resulting F_2 progeny always segregate on the basis of three plants with and one plant without leaf-marking, indicating a single factor difference between the presence and absence of markings. Plants without leaf-markings are constant and true breeding in respect of this character.

A number of strains characterised by the absence of leaf-marking were especially produced for these investigations. In order to ensure an ample supply of pure seeds the initial crosses were made under glass by means of clean bees. The seedlings used in all the tests were raised in sterilized soil and carefully examined for leaf-markings before and after planting in the field.

1926-27 Isolation Tests.

In 1926, 180 seedlings of Strain 201 and 780 seedlings of Strain 793 were planted in separate plots at about fifty yards apart on the same area as about 4,000 other seedlings nearly all of which had leaf-markings. The size of 201 and 793 plots, both of which were completely surrounded by plants with leaf-markings, was 48 and 270 square yards respectively.

In the spring of the following year, 300 seedlings of Strain 793 were isolated in another field. This plot, which was about 110 square yards in size, was fairly well isolated—the nearest possible source of contamination being a three-acre crop of Montgomery red clover at about 840 yards distant.

The plants on the 1926 plots bloomed in profusion in 1927, but those on the isolated plots produced only a few flower heads, the average being about two heads per plant. In the autumn of

1927 about 400 ripe heads were picked at random from each of these test plots. The seeds were rubbed out by hand and sown in the following spring. The seedlings, when about six inches high, were examined for presence of leaf-markings. The results obtained were :—

Strain.	*Distance from other red clover.*	*Size of plot sq. yards.*	*Age of crop.*	*Number of seedlings with (+) and without (0) leaf-markings.*		*Percentage contamination.*
				0	+	
201	Adjacent.	48	2nd year.	187	52	21.7
798	Adjacent.	270	2nd year.	271	34	11.1
798	340 yards.	110	1st year.	438	224	33.8

Since the seed plants were pure for absence of leaf-markings it is evident that all their offspring which had leaf-markings had been produced as a result of cross-fertilization by pollen of plants showing the dominant character. Therefore, the number of seedlings with leaf-markings appearing among the offspring gives a fairly reliable indication of the extent to which the strain has been contaminated by extraneous pollen.

As may be seen from the above data, the 798 plot planted in 1926, although surrounded by numerous plants with leaf-markings, was contaminated only to the extent of 11.1 per cent. The same strain planted in 1927, despite the fact that it was separated by a distance of 340 yards from any other red clovers, was contaminated to the extent of 33.8 per cent. The explanation of these results is to be found in the difference in the number of blooms produced on the two plots. The second year crop had such a large number of heads in bloom at the same time that the bees could obtain within a small compass all the nectar they were able to collect during one visit. The first year crop, on the other hand, produced very few heads, with the result that the number of florets in bloom was insufficient to retain the bees on the plot for any length of time, consequently the bee population on this area was continually changing, and each new arrival brought with it a fresh supply of foreign pollen.

From a comparison of the results given by the two second year crops it will be seen that 201 plot, which was only about one-fifth the size of the 798 plot, gave a much higher percentage contamination than the larger plot. This is in accordance with expectation. Other conditions being equal, the greater movement

of bees, which necessarily occurs on a small plot, must result in the introduction of more foreign pollen.

1930-31 Tests.

In 1930, 1,820 seedlings of strain S.18 with no leaf-marking were planted on the Plant Breeding Station farm on a plot about 400 square yards in size. The nearest possible sources of contamination in the first year were one-third of an acre of spaced plants at a distance of about 280 yards and several thousands of plants in pots about 300 yards distant, and in the second year the two areas mentioned above, 3 acres of a commercial crop of English broad red clover at a distance of about 400 yards and about one acre of spaced plants about 350 yards away.

S.18 used in this test was a late flowering strain and consequently it flowered very sparsely in the first year; during August about 5 per cent. of the plants had from one to four flower heads each, while most of the others showed no signs of flowering. In the second year all the plants produced an abundance of blooms.

In September of the first year 200 ripe heads were collected at random from the plot, and in the second year a similar number of heads was picked round the edge of the plot to a depth of about four feet, while another sample was hand-picked from the middle of the plot. When ripe the whole plot was harvested, and in due course threshed, but owing to the wet weather which prevailed during the pollination period and again during harvesting, the seed yield obtained was very low, being at the rate of only 71 lb. per acre.

The seeds of the three samples of hand-picked heads and a small sample of seeds of the main crop were sown in boxes. The results obtained from examination of the seedlings for leaf-markings are given below :—

Strain.	*Age of crop.*	*Sample.*	*Number of seedlings with (+) and without (0) leaf-markings.*		*Percentage contamination.*
			0	+	
S.18	1st year.	—	111	90	44.78
S.18	2nd year.	Edge of plot ...	1172	49	4.01
S.18	2nd year.	Middle of plot	1258	25	1.95
S.18	2nd year	Main crop	1709	26	1.52

As seen from the data, in the first year as many as 44.78 per cent. of the flowers have been cross-fertilised by extraneous

pollen. This result is in close agreement with that given in the first year by strain 793, and is undoubtedly due to the same cause.

Considering that the plot was by no means well isolated—it had four distinct sources of possible contamination within a distance of 400 yards, the nearest being only 280 yards away—the results obtained in the second year were very encouraging. The main crop, with only 1.52 per cent. contamination, showed a high degree of purity. The results indicate that along the edge of the plot the number of flowers which had been fertilized by foreign pollen was more than twice as large as the number occurring in the middle—a fact which suggests that the bees when visiting the crop for the first time generally alighted on the flowers along the edge of the plot. Though the hand-picked heads from the middle of the plots gave a slightly higher percentage contamination than the main crop, the difference, which was only 0.87 per cent., is too small to be significant.

According to the usual procedure adopted at the Plant Breeding Station when dealing with pedigree red clover strains, the bulk crop harvested from the isolation plot under consideration was decobbed by a thresher specially constructed to facilitate cleaning, then hulled by a machine specially designed for the purpose, and the seeds were finally cleaned by means of a " Dosser " machine. Several other red clover strains with leaf-markings had been subjected to these various cleaning processes prior to S.18. The fact that the degree of purity of the main crops was found to be at least as high as that of the hand-picked sample, which was carefully rubbed out by hand in such a way as to preclude any possibility of mixing, is a clear testimony of the care taken by the technical staff in cleaning between each crop the various machines concerned.

In 1930 another strain (S.12) with no leaf-markings, was planted at Woodmoor, Chirbury, Montgomeryshire (Mr. M. S. Kinsey), the dimension of the plot being about 530 square yards. In this case the nearest red clover in flower was a five-acre field at a distance of about 500 yards. Contrary to the practice usually adopted in the case of small isolation islands, this plot was not protected from rabbits. Unfortunately the damage caused by rabbits in this case was so great that out of 2,400 seedlings planted only 150 survived into the second year. Even the survivors were so weak as to produce comparatively few blooms, and this is reflected in the extremely poor seed yield, only 6.7 gm.

being obtained from the whole plot. The results given by the seedlings raised from this seed are cited below :—

Number of seedlings with (+) and without (0) leaf-markings.		Per cent. contamination.
0	+	
1458	432	22.8

Despite the fact that the plot was spatially very well isolated, contamination proved to be particularly heavy. Obviously the number of flowers produced was not sufficient to induce bees to stay on the plots for any appreciable length of time.

1932-33 Tests.

In 1932 three other strains without leaf-markings, namely, S.107, S.111 and S.114, were isolated for seed at different centres.

S.107, an intermediate strain synthesised from Montgomery, Swedish late, English late and English broad red plants, was planted at the Plant Breeding Station Farm, 1,460 seedlings being planted on a plot of about 360 square yards. As there was another red clover plot consisting of about 5,000 plants, practically all of which had leaf-markings, in the same field at a distance of only 200 yards, the spatial isolation in this case was not satisfactory. There was, however, a difference of about two to three weeks in the time of maximum flowering of the two crops.

The S.107 produced an abundance of blooms in the second year and gave a moderately good crop of seed. The data given below were obtained on a sample taken from the bulk seed in the second year.

S.111 strain was planted at Peithyll, Bow Street, Cardiganshire (Captain G. L. Bennett Evans). This plot, which was about 800 square yards in size and consisted of 1,350 plants, was spatially well isolated, the nearest sources of contamination in both the first and second years being situated at a distance of about 500 yards. Unlike all the other strains used in these investigations, S.111 was an early flowering strain and consequently flowered quite freely during the autumn of the first year. A representative sample of ripe heads was taken in the first year. The crop bloomed very freely and produced a good yield of seed in the second year.

S.114, which is a highly inbred medium-early strain, was

isolated in an outlying field belonging to the Plant Breeding Station. This plot was about 350 square yards in size and consisted of 1,200 plants. It was fairly well isolated, the nearest other red clover being one-sixth of an acre of spaced plants situated at a distance of about 350 yards. Owing to the very heavy mortality which occurred during the first winter the stand in the second year was definitely thin.

The results given by S.107, S.111 and S.114 strains are summarized below :—

Strain No.	*Size of plots.*	*Nearest source of contamination.*	*Age of Crop.*	*Number of seedlings with (+) and without (0) leaf-markings.*		*Percentage contamination.*
				0	+	
S.107	360 sq. yds.	200 yards	2nd year	4060	43	1.05
S.111	300 sq. yds.	500 yards	1st year	868	49	5.88
S.111	300 sq. yds.	500 yards	2nd year	3947	52	1.30
S.114	350 sq. yds.	350 yards	2nd year	3683	112	2.95

Considering that the nearest source of contamination was only 200 yards away a very high degree of purity, 98.95 per cent., was shown by Strain S.107. Probably this is largely accounted for by the difference in the time of flowering of the two crops. An almost equally satisfactory degree of purity was shown in the second year crop of S.111, but S.114, as might have been expected from the thinness of the crop, was contaminated to quite an appreciable extent.

Strain.	*Size of plot (sq. yds.).*	*Distance of nearest source of contamination (yards)*	*Age of crop.*	*Comparative number of blooms.*	*Percentage contamination.*
S.18	400	280	1st year	Very few.	44.83
S.18	400	280	2nd year	Numerous.	7.52
S.111	300	500	1st year	Fairly numerous	5.88
S.111	300	500	2nd year	Numerous.	1.30

The data above, showing the percentage contamination of the first and second year crops of two strains, serve to emphasise one very important point, namely, the effect which an abundance of bloom has on purity. Probably it is no exaggeration to state that the purity of a crop depends more on the freedom with

which it blooms than on the distance separating it from other crops.

General Conclusions.

The extent to which a pure-bred red clover strain is contaminated by extraneous pollen through the agency of bees depends on two major considerations : the distance separating it from other red clover crops and the profusion with which it flowers. Complete spatial isolation is seldom possible. Crops with comparatively few blooms were found to be heavily contaminated when isolated at distances ranging from 300 to 500 yards, but even at this distance apart a high degree of purity, from 98 to 99 per cent., was obtained from small plots 300 to 400 square yards in size if they had an abundance of bloom. As might be expected, a difference of two to three weeks between the time of flowering of the isolated strain and the nearest crops greatly lessened the chances of inter-pollination.

A small plot of 400 square yards of spaced plants may generally be relied upon to give in the second year from 20 to 30 lb. of seed, and this is sufficient to sow approximately four acres. An area of this size may be expected to yield about 1,200 lb. of seed, which in turn is sufficient to sow 150 acres.

It is obvious that small plots are much more apt to be contaminated by foreign pollen than large areas, and therefore the most critical period in the history of a new strain, in regard to its purity, is the second generation when it is being grown in a small plot for multiplication. If the necessary care is taken to keep a strain reasonably pure during this stage, no serious difficulty will be experienced in maintaining it at a high standard of purity in subsequent generations, if it is grown for seed on a fairly extensive scale and is moderately well isolated.

THE SOIL ESTABLISHMENT OF PEDIGREE AND COMMERCIAL STRAINS OF CERTAIN GRASSES.

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The investigations conducted at the Welsh Plant Breeding Station on the soil establishment of grass and clover species have made it evident that not only does the number of estab-

lished plants derived from one hundred viable seed vary from species to species, but that strains vary among themselves within the species (1, 2, 3).

It appeared desirable to carry out a trial on the soil establishment of strains of species under conditions containing no bias either to the commercial strains or to the pedigree indigenous strains.

The pedigree strains to be tested were Station grasses which are normally grown for seed production under different climatic conditions from the seed of commerce. In order to eliminate the possible effect of this factor on the comparison of the soil germination and subsequent establishment of the grasses, the officer in charge of Seed Production selected certain of the Station's pedigree strains and grew them alongside their commercial counterparts on two farms in the Clarach Valley, near the Station. All the grasses were harvested, therefore, under precisely similar conditions. A second consideration was that as the results in comparative soil establishment affect the farmer in the laying down of seeds mixtures the sowing and the after-management of the experiment should agree with farm practice. The experiment to be described was arranged so that statistical methods could be applied in the interpretation of the results.

The Experiment and Method of Procedure.

The field (Spring Field) on which this experiment was laid down was under plots of Italian rye-grass and subterranean clover during the years 1930 and 1931, and received 2 cwt. nitro-chalk and 3 cwt. superphosphate per acre in May, 1931. The field was ploughed in the autumn of that year and fallowed until the time of sowing the present trial (E.146) on April 5th, 1932. Basic slag at 5 cwt. per acre was applied in February prior to sowing the seeds.

As the custom is to sow " seeds " with a nurse crop, Garton's " Superb " oats were sown at the rate of 185lb. per acre. This particular variety was chosen as it is a moderately early maturing oat which stands reasonably well.

The main object of the investigation was to obtain comparison of the strains when growing in seeds mixtures. Only half the area was used for this purpose, however, for it was considered that the results for the strains in the seeds mixtures might usefully be compared with those for the same strains

grown in single species plots. The remainder of the area was accordingly sown out in this way.

TABLE I.

The species and strains used in the experiment with their grain weights. Also their seedings per acre in the single species plots.

Species.	*Strain.*	*Type.*	*Weight per 1,000 seed in gm.*	*Lb. per acre of viable seed.*
Perennial rye-grass	No. 1752	Late pasture.	1.426	25
	No. 1778	Early hay.	1.660	25
	Commercial	—	1.690	25
Italian rye-grass	No. 187	Leafy Italian.	2.504	30
	No. 189	Leafy Italian.	2.740	30
	Commercial	—	2.485	30
Cocksfoot	No. 1629	Pasture.	0.833	25
	No. 1308	Leafy hay.	0.770	25
	Commercial	—	0.738	25
Timothy	No. 310	Pasture-hay.	0.255	15
	No. 324	Chalk pasture.	0.265	15
	No. 326	Extreme pasture.	0.285	15
	No. 352	Leafy hay.	0.267	15
	Commercial	—	0.278	15
Meadow fescue	No. 123	Leafy hay.	1.728	30
	Commercial	—	1.675	30
Fine-leaved fescue	No. 728	Creeping red fescue	0.910	20
	Commercial	—	0.829	20

TABLE II.

The mixtures, in lb. per acre of viable seed, used in the test for soil establishments of the various strains.

Species in mixture.	*Strains under test.*					
	Perennial rye-grass	*Italian rye-grass*	*Cocks-foot.*	*Timothy*	*Meadow fescue.*	*Fine-leaved fescue.*
Perennial rye-grass	15	—	12	12	15	14
Italian rye-grass	8	25	3	3	—	3
Cocksfoot	6	—	9	6	6	6
Timothy	4	—	4	8	4	4
Meadow fescue	—	—	—	—	8	—
Fine-leaved fescue ...	—	—	—	—	—	4
Crested dogstail	1	—	1	1	1	2
Rough-stalked meadow-grass ...	1	—	1	1	1	—
Broad red clover ..	1½	1½	1½	1½	1½	1½
Late-flowering red clover	1½	1½	1½	1½	1½	1½
Alsike clover	1	1	1	1	1	1
Wild white clover	½	—	½	½	½	½

The species and strains used in the investigation, with particulars of their seedings, are shown in Tables I and II. It will

be observed that six species were used in the trial with a varying number of strains within each species.

The structure of the experiment was on the randomized block method, and was laid down according to the principles of Fisher and Wishart (4). The resulting figures for soil establishment have been subjected to the analysis of variance described by those authors. Five traverses of plots were taken across the area and each group of strains of the same species was considered as a block. These six blocks were randomized within each traverse. Next, the strains within each block were randomized.

The plots were 1/134th of an acre, and totalled 170. The number of pounds of seed per acre shown in Tables I and II are those of viable seed, and the number of viable seed per unit area used to obtain the percentage soil establishment is based on the weight of seed per 1,000. The compounding of the mixtures was in accordance with farm practice, with the exception that where timothy strains were under test their seedings were placed higher. The method of testing the strains was to use the same mixture for each strain within a species.

The data on the number of plants were obtained by throwing at random a 6in. × 6in. mesh twenty times on each plot. As there were five replications of each plot this meant 100 readings per individual grass. The first count was made in November of the seeding year, the second in the following spring, and the third in the autumn of the first harvest year.

The plots were grazed during the autumn following sowing. Hay was taken in the first harvest year followed by successive grazings.

Results.

The data from the single species plots are presented in Table III, and those for the investigated strains growing in mixtures in Table IV. A paragraph of remarks accompanies each table. As previously mentioned, the arrangement of the experiment was on the randomized block method. An analysis of variance has therefore been made for each group of strains comprising a species block, and tests of significance between the strains have been made by means of Fisher's table of *t* (5, chapter V).

TABLE III.

The mean percentage establishment of the strains in the single species plots with the significant difference.

Species.	Strain.	First count: Nov., 1932.		Second count: Mar., 1933.		Third count: Nov., 1933.	
		Means.	Significant differences.	Means.	Significant differences.	Means.	Significant differences.
Perennial rye-grass	No. 1752	19.7	1 per cent. pt. = 4.28	15.0	1 per cent. pt. = 3.67	26.6	1 per cent pt. = 3.27
	No. 1778	24.1	5 per cent. pt. = 2.95	19.3		29.9	5 per cent. pt. = 2.25
	Commercial	23.4		19.1		29.6	
Italian rye-grass	No. 187	27.4		24.3		27.4	
	No. 189	28.1	No significance.	25.8	No significance.	26.6	No significance.
	Commercial	29.7		24.9		24.8	
Cocksfoot	No. 1629	10.4		7.8		10.4	
	No. 1303	11.0	No significance.	9.4	No significance.	10.5	No significance.
	Commercial	11.2		9.8		10.3	
Timothy	No. 310	4.1		6.0		9.9	
	No. 324	4.1		5.8		8.8	
	No. 326	4.1	No significance.	5.7	No significance.	9.6	1 per cent. pt. = 1.855
	No. 352	4.9		6.3		9.9	
	Commercial	4.9		7.5		11.9	
Meadow fescue	No. 123	15.8	No significance.	18.6	No significance.	22.5	No significance.
	Commercial	16.1		18.3		20.4	
Fine-leaved fescue	No. 728	12.0	1 per cent. pt. = 1.75	—	—	—	—
	Commercial	9.9					

TABLE IV.

The mean percentage establishment of the investigated strains growing in the seeds mixtures with the significant differences.

Species.	Strain.	First count: Nov., 1932.		Second count: Mar., 1933.		Third count: Nov., 1933.	
		Means.	Significant differences.	Means.	Significant differences.	Means.	Significant differences.
Perennial rye-grass	No. 1752	28.2		29.7		30.2	
	No. 1778	36.3	1 per cent. pt. = 6.58	37.5	1 per cent. pt. = 5.62	34.1	5 per cent. pt. = 3.11
	Commercial	39.4		40.7		34.6	
Italian rye-grass	No. 187	40.4		29.5		26.7	
	No. 189	38.4	No significance.	31.9	No significance.	27.7	No significance.
	Commercial	38.9		30.2		25.5	
Cocksfoot	No. 1629	6.4	1 per cent. pt. = 5.78	4.2		9.0	
	No. 1808	11.4	5 per cent. pt. = 3.98	7.6	1 per cent. pt. = 2.78	12.9	5 per cent. pt. = 2.73
	Commercial	17.3		9.2		12.7	
Timothy	No. 324	2.3	1 per cent. pt. = 1.588	2.2	1 per cent. pt. = 3.122	1.9	1 per cent. pt. = 1.142
	No. 352	4.4	5 per cent. pt. = 1.092	4.8	5 per cent. pt. = 2.142	3.1	5 per cent. pt. = 0.787
	Commercial	5.7		6.8		3.9	
Meadow fescue	No. 128	2.9	5 per cent. pt. = 1.795	3.4	5 per cent. pt. = 2.58	7.5	No significance.
	Commercial	4.9		6.5		8.3	
Fine-leaved fescue	No. 728	34.8	1 per cent. pt. = 6.92	44.2	1 per cent. pt. = 18.20	—	—
	Commercial	28.7		22.5			

Remarks on Table III.

First count. Perennial rye-grass, at 1 per cent. point No 1778 exceeded No. 1752[1] at 5 per cent. point commercial exceeded No. 1752[2]. No significant difference between commercial and No. 1778. Fine leaved-fescue, at 1 per cent. point No. 728 exceeded commercial.

Second count. Perennial rye-grass : at 1 per cent. point No. 1778 exceeded No. 1752. No significant difference between commercial and No. 1778.

Third count. Perennial rye-grass : similar to the first count : timothy, at 1 per cent. point commercial exceeded all pedigree strains. No other significant differences.

Considering the data from the single species plot first (Table III with remarks) it will be observed that the relative positions among the perennial rye-grass strains for the three counts are extremely consistent. The Italian rye-grass, cocksfoot and meadow fescue strains have shown no significant differences in these plots. At the first count the pedigree fine-leaved fescue is significantly greater than the commercial on the more severe test. These fine-leaved fescues crept so rapidly that plant counts could not be made on the pure plots after November, 1932, and on the mixture plots after March, 1933.

Remarks on Table IV.

First count. Perennial rye-grass : at 1 per cent. point commercial and No. 1778 exceeded No. 1752. No significant difference between commercial and No. 1778.

Cocksfoot : at 1 per cent. point commercial exceeded Nos. 1629 and 1303. At 5 per cent. point No. 1303 exceeded No. 1629.

Timothy : at 1 *per cent. point commercial and No. 352* exceeded No. 324. *At 5 per cent. point commercial exceeded* No. 352.

Meadow fescue : at 5 per cent. point commercial exceeded No. 128.

Fine-leaved fescue : at 1 per cent. point No. 728 exceeded commercial.

Second count. Perennial rye-grass, meadow fescue and fine-leaved fescue : similar to the first count.

Cocksfoot : at 1 per cent. point commercial and No. 1303

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1 At 1 per cent. point the probability is 100 to 1 that the difference is significant.

2 At 5 per cent. point the probability is 20 to 1 that the difference is significant,

exceeded No. 1629. No significant difference between commercial and No. 1303.

Timothy : at 1 per cent. point commercial exceeded No. 324. At 5 per cent. point No. 352 exceeded No. 324. No significant difference between commercial and No. 352.

Third count. Perennial rye-grass : at 5 per cent. point commercial and No. 1778 exceeded No. 1752. No significant difference between commercial and No. 1778.

Cocksfoot : at 5 per cent. point commercial and No. 1303 exceeded No. 1629. No significant difference between commercial and No. 1303.

Timothy : similar to the first count.

TABLE V.

The mean percentage establishment of each pedigree grass placed relative to the commercial at 100.

		Single species plots.			*Mixture plots.*		
Species.	*Strain.*	*Nov. 1932*	*Mar. 1933*	*Nov. 1933*	*Nov. 1932*	*Mar. 1933*	*Nov. 1933*
Perennial rye-grass	No. 1752	84	79	90	72	73	87
	No. 1778	103	101	101	92	92	99
	Commercial	100	100	100	100	100	100
Italian rye-grass	No. 187	92	98	107	104	98	105
	No. 189	95	104	111	101	106	109
	Commercial	100	100	100	100	100	100
Cocksfoot	No. 1629	93	80	101	37	46	71
	No. 1303	98	96	102	66	83	102
	Commercial	100	100	100	100	100	100
Timothy	No. 310	84	80	83	—	—	—
	No. 324	84	77	74	40	32	49
	No. 326	84	76	81	—	—	—
	No. 352	100	84	83	77	71	80
	Commercial	100	100	100	100	100	100
Meadow fescue	No. 123	98	102	112	59	52	90
	Commercial	100	100	100	100	100	100
Fine-leaved fescue	No. 728	121	—	—	147	196	—
	Commercial	100	—	—	100	100	—

Turning next to the data from the mixture plots (Table IV with remarks) the strains of cocksfoot and meadow fescue have now exhibited significant differences as well as the strains of perennial rye-grass, timothy and fine-leaved fescue. The strains of Italian rye-grass have exhibited no significant differences throughout the experiment. It is interesting to note that the perennial rye-grass strains have shown precisely similar relationships in both the single species plots and the mixture plots, except that there is some variation as to the point of significance. While there was a significant difference in favour of the

commercial meadow fescue at the first count, that difference had disappeared by the last count.

In order to assist the comparison of the means from a relative standpoint, the means of each pedigree strain have been expressed in Table V relative to the commercial at 100.

Discussion.

The data have conclusively shown that of the species under test the strains within each species have differed in their soil establishment with the exception of Italian rye-grass.

The commercial strains have usually been among the highest in soil establishment, but in the case of perennial rye-grass, cocksfoot and meadow fescue a pedigree strain has given equal results by the last count in the mixture plots, while for fine-leaved fescue the pedigree strain has proved superior throughout. It is only for timothy that the commercial strain has proved significantly better than the pedigree strains.

A comparison between the single species plots and the mixture plots shows that the strains which exhibited the poorest establishment in the mixture plots gave figures equal to their fellow strains in the single species plots. Davies (6) has shown that species in competition with the rapidly establishing rye-grasses are suppressed in their own establishment. It is evident that in the present trial, competition has been the cause of the particular behaviour of the strains in question.

The relative figures for the mixture plots (Table V) indicate that the pedigree strains gave soil establishments nearer to those of the commercial strains by the last count. Reference to the actual means (Table IV) will show that there has been a rise in some cases and a fall in others over the period of the experiment irrespective of the strain. There have evidently been several factors at work to account for this fluctuation. First of all, death of plants would account for the fall in numbers, and Davies (7) has shown that considerable plant casualties take place in a sward during the first year. Secondly, Stapledon, Davies and Beddows (1) and Davies (6) have shown that delayed germination and latency of seedling growth occurs among species. These two factors, if exceeding the effect of mortality, would account for an increase in plant numbers over the period.

It is to be supposed that these factors have been operating upon commercial and pedigree strains alike. The net result, however, is that the soil establishments of the pedigree strains

has been brought nearer to those of the commercial strains by the end of the first harvest year.

Western (3) found that commercial strains of grass gave a higher soil germination and more vigorous growth during the early period of the life of the plant than indigenous pedigree stains, but that this early superiority became less marked as time went on. The data of the present trial indicate that this equalizing of the strains is carried on from initial establishment to final establishment.

In connection with the problem of delayed establishment, Chippindale (8) found " . . . that it is possible for certain species of grass ultimately to attain satisfactory establishment following on little or no germination, as the persistence of their seedlings enables them to await the arrival of conditions suitable for their development," and that on the removal of competition, as would take place in a grazed sward, the seedlings are capable of immediate recovery. As the management of the present experiment was such as to check competition after the initial period, there is reason to believe that the recovery of cocksfoot No. 1629 and of the pedigree meadow fescue in the mixture plots has a bearing on the findings of Chippindale.

Davies (7) found a direct positive correlation between grain weight and percentage soil establishment. Reference to Table I, where the grain weights (weight per 1,000 seed) of the strains used in the present trial are given, will show that the behaviour of the perennial rye-grass, timothy and fine-leaved fescue strains coincide with his results, the heavier seed giving the higher establishment. In regard to the other species, no significant differences occurred in their pure plots, and in the mixture plots this factor would be masked by others, notably that of competition.

The behaviour of the species in relation to each other, such as the low establishment of the cocksfoot and timothy, compared with the rye-grasses, agrees with the earlier work on the subject (1), and the lower establishment of meadow fescue when in competition with the rye-grasses compared with the far superior figures for the pure plots, coincides with results reported upon by Davies (6).

Summary.

1. An investigation into the soil establishment of pedigree grass strains compared with commercial strains of the same species has been conducted on a statistical basis.

2. Significant differences occurred among the strains of

perennial rye-grass, cocksfoot, timothy, meadow fescue and fine-leaved fescue, but none among the Italian rye-grass strains.

3. When significant differences occurred among the investigated strains growing in seeds mixtures, a pedigree strain gave equal results with the commercial strain in perennial rye-grass, cocksfoot and meadow fescue. In timothy, the commercial strain gave a superior result to all pedigree strains, but in fine-leaved fescue an inferior result.

4. Few significant differences occured among the strains growing in single species plots.

5. Where there has been a wide difference in the soil establishment among the strains in the autumn of the seeding year, that difference has become less marked by the following spring and autumn.

6. The factors accounting for this behaviour have been discussed.

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PROLIFERATION IN CYNOSURUS CRISTATUS.

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In the description of grasses in most books of reference vivipary is described as occurring more or less frequently in several species. As Arber (1) has pointed out, the use of the term vivipary should be discontinued where proliferous growth in grasses is concerned. The viviparous growth mentioned by Ward (2) includes proliferation as here described. Kennedy (3) avoids the term vivipary when referring to the formation of bulbils in *Poa bulbosa*. In the absence of any precedent in nomenclature, avoiding at the same time an incorrect use of the word vivipary the terms " proliferation of the barren and floral spikelets " will be used for this paper. The former represents a growth phase of the apical leaves on the barren spikelets, the latter the apogamous development of the floral parts into plants. The term bulbil as applied to the proliferous growth of *Poa bulbosa* cannot here be used, as this implies a normal shedding and an independent existence of the vegetatively produced plants at some period in development, a feature absent from Cynosurus. It has no connection whatever with the " Green ear " disease (*Scherospora graminicola*) on Bajra (*Pennisetum typhoideum*) in India as described by Chaudhuri (4). There is an entire absence of leaf shredding and when the barren spikelets only are affected viable seeds are produced. It is not a pathological disturbance for as far as is nown there is no causal organism.

In New Zealand the prevalence of prolifery in certain grasses, particularly in *Cynosurus*, *Dactylis*, and *Phleum*, is well marked, and it has been noted particularly in the lowlands of the Wellington province where the rainfall is ample and well distributed and the soil rich. In pastures and along roadsides one can frequently see, especially during autumn, numerous proliferous heads standing out green and conspicuous well above the remainder of the foliage. This phenomenon has been particularly prevalent in experimental plots at Massey Agricultural College, Palmerston North, on spaced plants of *Cynosurus cristatus*, and the following observations have been made on

these. Though noted before, close observations were first made in 1930 and these were continued in 1931.

During the autumn and winter of 1930 the abnormal heads were more abundant than usual. They were most frequent on out of season shoots, i.e., shoots which developed after the removal of the main crop of seed heads, (*cf.* Jenkin (5)) though abnormalities did occur amongst the harvested heads. The abnormalities were of two types :—

1. Proliferation of the barren spikelets.
2. Proliferation of the floral spikelets.

In the spring and early summer 1930-31 from observations on approximately 10,000 spaced plants only one showed any sign of abnormality before the plants were cut back at the end of January. This plant showed proliphery of both barren and fertile spikelets. By February 10th, 1931, out of 260 plants which were not cut back 40 were showing distinct signs of developing proliferation of the barren but not the floral spikelets. This growth commenced after the seeds[1] had matured and in many cases fallen. In the previous season, however, this character made its appearance earlier and was coincident with the development of the seeds. By the time the seeds were shed proliferation was well advanced, and some of the heads were quite green. This character was not associated with any particular regional strain and was equally apparent on both early and late flowering plants. Where seed had been sown in plots at the rate of 20 lb. to the acre no proliferating heads were noted in the normal hay crop, but they were very numerous in the second crop of seed heads.

Types of Growth. In *Cynosurus* there are two forms of spikelets, (a) the fertile spikelets composed of 5—12 flowers, and (b) the barren spikelets consisting each of a central stalk or axis from which a varying number of overlapping bract-like leaves arise alternately. These have previously been described by Arber (1) and a reiteration is not necessary here. As already explained, the proliferous growth may take the form of an extension of growth of the apices of the barren spikelets or vegetative growth may entirely displace the floral organs. On some heads the flowers may develop normally to produce viable seeds while the barren spikelets (on the same heads) are showing proliferous growth. Though this vegetative growth may be active while the seeds are developing, it becomes decidedly more pro-

[1] The term seeds is here used instead of fruits in conformity with Agricultural nomenclature.

nounced after they are shed. In many cases the barren spikelets commence to proliferate only after the seeds have ripened. Thus there may occur proliferation of the barren spikelets coincident with the normal functioning of the fertile spikelets, or both barren and fertile spikelets may vegetate together. No case has been noted of the proliferous growth of the fertile spikelets without corresponding growth in the sterile ones.

Mode of Development of the Barren Spikelet.

Arber (1) has described an early intermediate stage in the process of development from the normal barren spikelet of *Cynosurus cristatus* to a mature plant. In New Zealand the vegetatve growth is carried on to a much more complete stage than Arber describes, in fact the development in its several forms can be said to have been completed. There appears to be no record of the complete cycle having been previously noted.

The first appearance of continued growth of the sterile spikelet is at or near the apex (See Fig. I *a—e*) and this may occur even though the whole head has otherwise apparently lost its chlorophyll and turned a straw colour. The upper two, three or four leaves alone on each barren spikelet continue to grow; the lower ones die and are eventually shed from above downwards. The lowermost pair may remain attached to the stalk a considerable time. A meristimatic region forms near the apex of the axial stalk at the point of attachment of the upper leaves and it is from this that all subsequent proliferous growth is made. There then follows a reformation of chlorophyll and a foliar development of the bract-like leaves. The growth becomes differentiated into leaf and sheath (Fig. 1*e*) as in the parent grass. From this point leaf growth develops normally. (Fig. 8*a*).

One, two or more usually three, rootlets appear when the vegetative growth reaches about ½ inch in length, and their emergence is thus some weeks after the active growth has commenced on the shoot.They pierce the sheath a short distance above the point of attachment of the young plant to the axillary stalk of the barren spikelet. Fig 2 *a—r* shows three rootlets at an early stage in development.

While the flowering stalk of the parent plant remains erect the roots remain as small protuberances and do not develop further. If the air is moist they may persist, but if dry, and particularly if there is a wind, they perish.

During autumn and early winter (the weather is usually mild and air moist) the vegetative plants develop rapidly and


Fig 1.
c
d
a
b
e
a
b
Fig 2
Fig 3.
a
c
a

a b

FIG. 5.

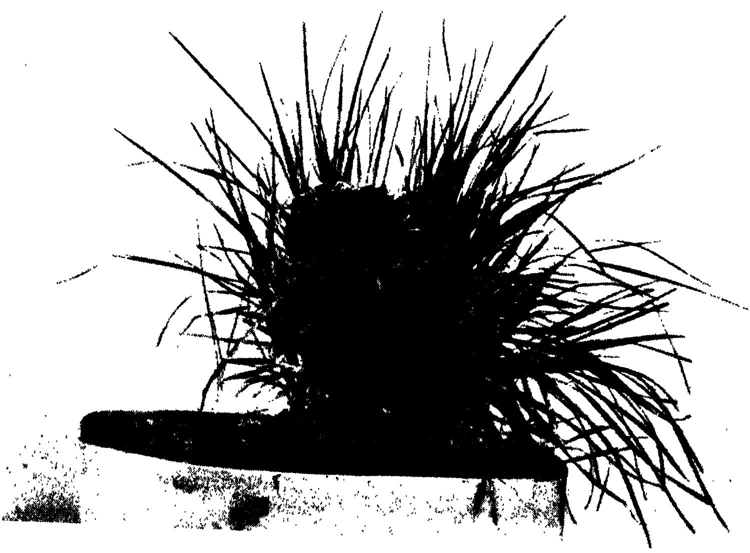

FIG. 6.

the short stems increase in diameter and to some extent downwards so that after the lower unchanged leaves of the barren spikelet have been shed the young plants may appear to be attached directly to the rachis. With the increase in weight consequent upon this increase in size, the flowering stalk may or may not bend over and become horizontal. Failing any movement the young plants may persist over winter but usually perish with the dry spring winds. This is not invariably the case for where the flowering stalks are short and they are sheltered by the leaves of the parent plant they may still develop. (See Fig. 6.) Those whose weight bears them down to the ground frequently develop further, and the rootlets, if they have not been previously dried up commence active growth with the increase in shade, shelter, and moisture, enter the ground and anchor the plants. By the spring they may have formed a colony of plants equal in size to the parent plant (See Fig. 5. *a* is the parent plant, *b* the colony formed vegetatively.) This means that a considerable amount of growth has taken place as the parent plants are spaced for observational purposes and are much larger than those found under grassland conditions. From the time the rootlets enter the ground development appears normal as for seedlings. It is interesting to note, however, that where the original rootlets of the proliferous plants have perished through exposure or other cause, the formation of new ones is not rapid. Nor is their replacement necessary for full growth to take place, as sufficient food material can and does pass along the flowering stalk to support them adequately without roots of their own. Fig. 7 shows four proliferous heads produced by one plant; the leaves of the parent have been removed to show the two lower ones. The more erect and exposed proliferating heads have not developed to the stage reached by those which have more shelter. This is a general feature which has been observed in both years. Development of the proliferating heads is made possible through the continuance of conductivity in the flowering stalks. Under normal conditions when seeds have been shed the stalks cease to function further and die off, but where proliferation is present then they persist throughout the winter and have been observed to function for over twelve months after the flower heads were first produced. Fig. 8 shows a later stage of the same plant shown in Fig. 7 and illustrates the final stage to which observations have been carried.

As the vegetatively produced plants shown in Figs. 7 and 8 failed to develop root systems of their own, the only source of food material from the soil has been by way of the flowering stalk. The efficiency of the stalk as a conducting medium can be gauged from the fact that the conducted food material has been sufficient to provide not only for the development of leaf and stem growth in the vegetative plants, but has enabled them to produce flower heads which contained viable seeds. The plants which developed on the head *d* produced 15 seed heads and those on head *c* produced 10. Neither of the erect heads *a* and *b* developed to the stage beyond that shown in Fig. 7. The flower heads so produced by the vegetative plants were on the average only slightly smaller than those produced at the same time by the parent plant, and some in fact were equally as large as the largest of the parental ones.

Proliferation of the Fertile Spikelets.

The fertile spikelets when they commence to vegetate do so more slowly and less vigorously than the barren ones. Fig. 4 shows a fertile spikelet at an early stage in proliferous development, together with a normal fertile spikelet *a*, and a proliferous barren spikelet *c* for comparison. No detailed study of the change which occurs in the different floral parts has been made but undoubtedly the glumes play the most prominent part in leaf development.

The flower heads that are produced in autumn are more likely to develop prolifery of the fertile spikelets than those produced in summer. The later the heads are in emerging the greater is the likelihood of vegetation of the floral parts to occur. This urge becomes so strong in the late heads that some have difficulty in emerging from the sheath owing to an advanced stage of prolifery having been reached while still enclosed. The occurrence of these extreme cases is relatively rare.

Discussion.

The fact that prolifery occurs most readily in New Zealand on three grasses which are strongly caespitose in habit, i.e. *Dactylis glomerata*, *Cynosurus cristatus*, and *Phleum pratense*, suggests that these plants are making an effort to overcome this disability. A further effort is made also by *Cynosurus*, as evinced by its behaviour in a well grazed open sward. After maximum growth has taken place during summer, the central shoots of the plant may die away leaving a few of the younger peripheral ones. In this way the plant becomes broken up into two, three or four (there are seldom more) smaller plants, separated from each other by the dead shoots. Thus where one

FIG. 7.

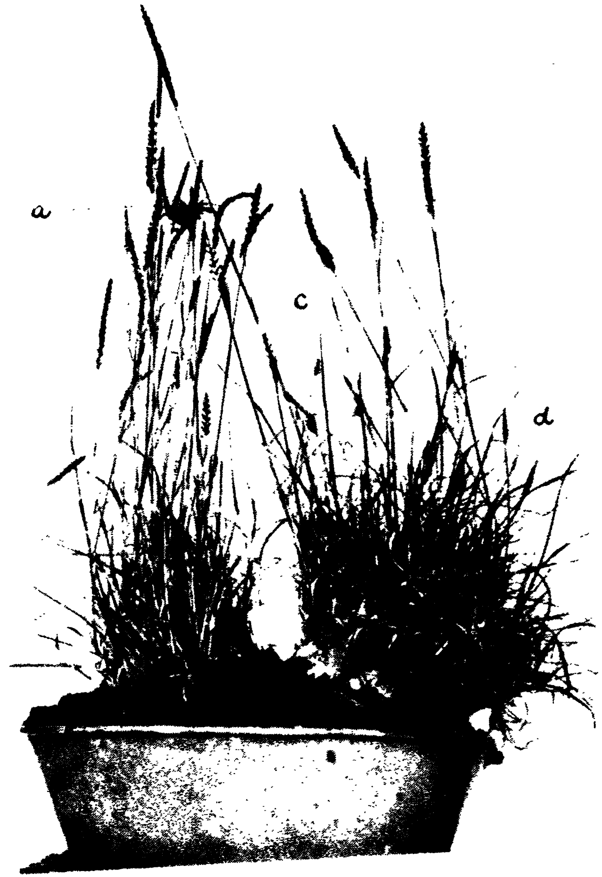

FIG. 8.

large plant previously existed there are now two, three or four smaller ones which gradually become detached from each other at the base and become independent after forming adventitious roots of their own. There is thus a possibility of the continual rejuvenation of the plant around the periphery, a type of natural clonal development from young shoots. Owing to the inability of this plant to develop freely an abundance of new roots, what would otherwise be a highly satisfactory method of vegetative propagation is negatived. These secondary plants seldom attain the size of the parent owing to the sparcity of the root system they develop and they lack the vitality of the plant developed from seed. Thus unless this process occurs under ideal conditions the plant is short lived.

A further feature of interest is the continued conductivity of the flowering stalk of the proliferating heads. There appears to be an increased functioning and rejuvenation of this stalk when proliferation commences. In some cases a flowering stalk which externally differs in no way from stalks which are dead, commences to function and proliferous growth of the barren spikelets is initiated even though some weeks have elapsed since the seed was shed. The recommencement of growth cannot be attributed to alteration in moisture or controlable manurial conditions, for such changes have commenced in the height of the dry season when there has been little or no rain and the ground very dry and no manure had been applied to the soil for twelve months.

EXPLANATION OF FIGURES.

Fig. 1.—The commencement of proliferous growth in the barren spikelets progressing from *a* to *e*. Only the upper four or five leaves become foliate, the remainder are shed. (x 2¼).

Fig. 2.—*a*—A young vegetable plant showing three rootlets which have emerged from the sheath.

b—A normally developed floral spikelet at the front with a proliferating barren spikelet behind. (x 2).

Fig. 3.—A vigorous proliferating head. Proliferation is entirely confined to the barren spikelets.

a—One of the vegetative plants. (Nat. size).

Fig. 4.—*a*—Normal fertile spikelet.

b—Fertile spikelet which has commenced to proliferate.

c—The corresponding barren spikelet which has reached a much more advanced stage of proliferation. (x 2¼).

Fig. 5.—The appearance in early spring of a colony of plants (*b*) which have developed from one proliferated head produced by the parent plant *a*. The arrow shows the persistent flowering stalk of the head. (One-third Nat. size).

Fig. 6.—A developing proliferous head sheltered by the leaves of the parent plant. The weight of the head is insufficient to bear it to the

ground. Under such circumstances an effective root system cannot be developed. (One-third Nat. size).

Fig. 7.—A plant which has produced four proliferating heads. The leaves of the parent plant *e* have been removed to better show the heads *c* and *d*. Photo taken Oct., 1930. (One-fifth Nat. size).

Fig. 8.—A later stage of the same plant as shown in Fig. 7. (Dec., 1930). Head *a* has failed to develop further, head *b* died and the stalk broke off. The proliferous plants on head *c* produced ten flowering heads and those on head *d* fifteen flowering heads. There were no effective roots produced by any of the vegetative plants. (One-fifth Nat. size).

Photos 1, 2, 3, 4, by M. T. Gabriel;
5, 6, 7, and 8 by W. A. Jacques.

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SOIL SURVEY OF WALES.

PROGRESS REPORT, 1931-34.

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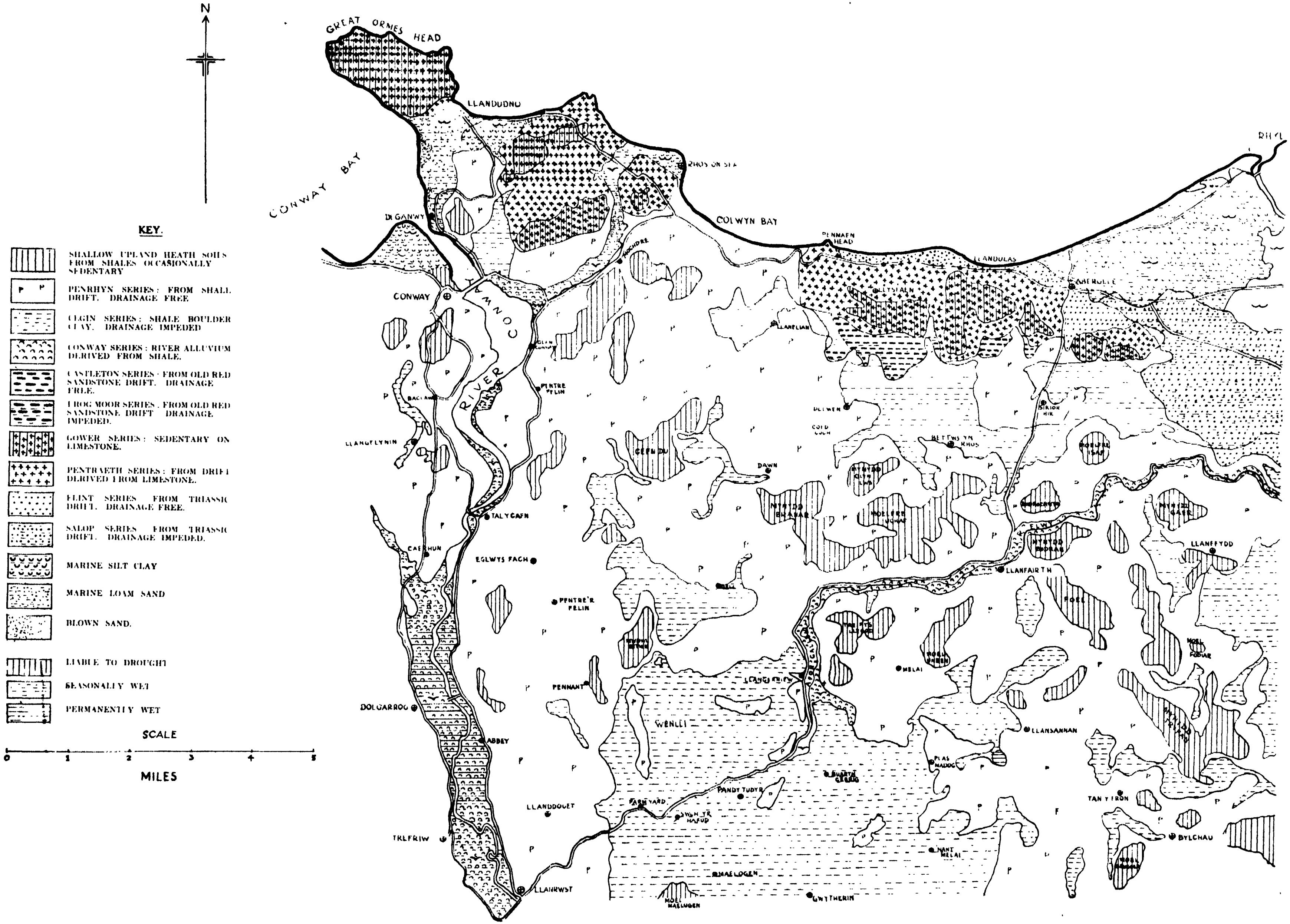
Since the last report (this *Journal*, Vol. VIII, 1932) field work has proceeded in North Wales, principally in Anglesey and in North-west Denbighshire. In addition, detailed advisory surveys of small areas have been made in Merionethshire, Caernarvonshire, Flintshire and East Denbighshire.

The work described in the present report relates to two areas, namely, N.W. Denbighshire and N.E. Caernarvonshire, and Anglesey. In the latter area, the country mapped continues on from the area described in previous reports and the soils of the island are now considered as a whole.

The principles underlying the Soil Survey have already been set forth in the report contained in this *Journal* (Vol. VI, 1930).

FIG. I.
SOIL MAP OF N.W. DENBIGHSHIRE.



The correlation of soil survey throughout Great Britain is now in the care of a committee appointed by the Ministry of Agriculture.

N.W. DENBIGHSHIRE AND N.E. CAERNARVONSHIRE.

The area surveyed is shown in Fig. 1. It comprises that part of Denbighshire west of a line from Abergele to Nantglyn and north of a line thence to Llanrwst. It includes also that part of Caernarvonshire along the west of the Conway valley from Conway to Dolgarrog.

Topography.

With the exception of alluvial flats, and certain small areas of drift lying along the coast, the area has strong surface relief. The outline is very irregular, surface forms varying from sharply defined hills, several of which attain a height of over 1,200 feet to the rolling or undulating outline of the lower ground.

Along the north of the area, the high steep-sided ridges of limestone mainly determine the coast outline from Abergele to the Great Orme, and are prominent features of the landscape. Southward, with diversity of feature, the average elevation gradually increases and throughout the southern half of the area, there is very little land lying below 600 feet. The upper limit of cultivation is at about 1,100 feet, whilst there are extensive cultivated portions lying above 900 feet.

Drainage.

The Elwy is the chief river of the district. Though the area directly within its basin is not extensive, the Elwy is the outlet of numerous tributaries notably the Aled and Cledwen, which collectively serve to drain most of the interior. Among the smaller systems are the Dulas, which drains a considerable area in the lower ground surrounding Bettws and Dolwen, eventually flowing north to the sea at Llandulas; and the Hiraethlyn, which drains into the River Conway near Tal-y-Cafn. With this exception, the area drained into the Conway is limited to the immediately adjoining slopes.

In the Caernarvonshire portion of the area the Gyffin drains a small valley northwards into the estuary of the Conway, whilst the remainder is drained directly into the Conway by minor streams.

Climate.

As would be expected in a region of diverse outline and altitude, there is appreciable variety in the climate of the area.

In the coastal regions, the conditions are maritime, with mild winters and cool summers. Inland and with greater elevation, more rigorous conditions prevail. The rainfall, closely related to surface relief, varies widely. On the lowland from Llandudno to Abergele the average annual rainfall amounts to about thirty inches. On the higher ground the total may exceed fifty-five inches per annum. Although the rainfall is highest in the uplands, the shallow character of the soils and free drainage intensify the effects of dry periods. Drought becomes a limiting factor of growth and determines a heath type of vegetation characteristic of these areas.

Geology.

The rocks of the area belong to three geological systems, namely, Silurian, represented by Wenlock Shales and associated fine-grained grits; a small strip of Old Red Sandstone, represented by micaceous sandstone and marl; and Carboniferous Limestone. In addition there is an area of boulder clay derived from Triassic rocks, and extensive tracts of estuarine alluvium of mixed origin.

The Soil Series of the Area.

In an earlier volume of this *Journal* (Vol. VI, 1930), a description of the classification of Welsh soils was given. This system of classification, based essentially upon the character of the parent material and the mode of development, has been followed in the present Survey.

Before proceeding to describe the various soil series encountered, it should be noted that we are dealing with an area which almost invariably bears evidence of glaciation. This accounts for the limited occurrence of soils formed in situ and for the mixed composition of some of the drift. Areas free from glacial deposit are generally limited to the crests of the higher features.

The following soil series have been recognised; their distribution is shown on the accompanying map.

Parent Material.	*Series.*	*Types.*
Wenlock cleaved shales and fine-grained grits.	Powys	Shaly loam.
	Hiraethog	,, ,,
	Penrhyn	Light to medium loam.
	Cegin	Medium to heavy loam.
	Conway.	Shaly loam, clay silt and peaty silt.

Parent Material.	*Series.*	*Types.*
Old Red Micaceous Sandstone and Marl.	Castleton Frog Moor.	Light to medium loam. Heavy loam.
Carboniferous Limestone.	Gower Pentraeth	Light loam Light to medium loam.
Triassic Marls and Sandstone.	Flint Newport Salop	Medium loam. Sandy loam. Medium to heavy.
Estuarine Alluvium.	—	Loamy sand, clay silts.
Blown Sand.	—	—

In addition to these easily recognised series, there are soils derived from drift of mixed origin which cannot readily be classified, and which must be regarded as local series. The commonest mixtures are shale with Old Red Sandstone material and shale with Limestone residue. A number of these mixed types have been recognised, all being situated within a limited area in proximity to their sources of origin.

Powys and Hiraethog Series.

The sedentary soils of the Powys series are almost entirely confined to the uncultivated uplands. In general character they have affinities with the intermingling shallow drift soils, with which they may be classified.

These upland areas present a variety of soil conditions. Soil depth, which varies considerably according to the relief, ranges from thin coarse brash with very little matrix to the deeper profiles of colluvial origin. The sedentary soils which belong to the Powys series are usually limited to the crests of features.

The profile typical of most of this upland is of open texture with high content of organic matter in the surface layers. Drainage is very free and for considerable periods during an average summer, most of the area is subject to severe drought. The vegetation comprises a variety of heath associations. Most commonly it consists of fescues with varying complement of bracken. On the deeper phases bracken tends to predominate whilst gorse is usually in possession of the thinner soils.

Occasionally, on the flatter portions where conditions are more favourable to percolation there is a marked degree of podsolisation resulting in soils of the Hiraethog series. The profile varies from the shallow phase to the deeper well-developed podsols of the Hiraethog moorland lying further south. The

profile consists essentially of a peaty surface layer rich in acid humus, a pale grey horizon from which iron oxides have been removed by leaching, and a reddish-brown horizon in which iron oxides have been re-deposited. The podsols are usually under heath vegetation composed mainly of heather and bilberry.

As a whole, these shallow uplands are used as open sheep walks. There are instances of recent reclamation but the conditions are not favourable to lasting improvement. There is on the contrary widespread evidence of encroachment of the heath elements on to the lower ground. It may be noted that where reclamation is undertaken the usual procedure is to plough and re-seed with rape, which is consumed on the land by sheep. Seeding-down may be deferred even to the fourth year in order to ensure good conditions for the seed " take."

Penrhyn Series.

Soils derived from shale drift material with free drainage, are widespread throughout the area and together constitute the most important series. The soil types vary according to the character of the parent material. There are warm brown free-working stony loams with deep tilth found on the lighter drifts, and greyish-brown medium to heavy silt loams derived from the more compact heavier boulder clays. On the lower hill slopes deep friable soils formed on colluvial material are fairly common. In the more sheltered situations, these constitute some of the best soils of the series and would appear to be well suited for fruit production.

The analytical data of a large number of soils representative of the main types in the area indicate above all, a widespread deficiency of available phosphoric acid. In pasture lands this deficiency is generally denoted by the presence of bent grass, which, in the more neglected areas, constitutes the bulk of the herbage. In view of the fact that the area is largely devoted to stock rearing and thus largely dependant upon the yield of its pastures, this serious condition calls for consideration. The potash content of these soils is generally variable but mainly fairly satisfactory. The lime status is variable, and since these soils are naturally non-calcareous, the satisfactory status must be attributed to liberal treatment given in former years. It would appear, however, from present data that liming will soon be necessary on many of these soils if the present level of fertility is to be maintained.

Cegin Series.

Another extensive group of soils derived from shale boulder clay and characterised by impeded drainage constitutes the Cegin series. These poorly drained soils are of wide occurrence throughout the shale country. They form the predominant series of the southern half of the area, where they merge gradually into the open moorland of Mynydd Hiraethog.

The Cegin soils are, essentially, brownish-grey medium to heavy silt loams of shallow tilth over raw yellow or grey heavy subsoil closely resembling the unaltered boulder clay.

The degree of impedance varies and we have distinguished two broad categories. In the better type, largely under cultivation, poor drainage may be mitigated to a large extent by good management and in a dry season they may prove more productive than the freely-drained soils. On the poorer types, too wet for cultivation, the herbage is inferior and commonly dominated by rushes and sedges.

With regard to the moisture conditions of these soils as a whole, there is evidence that large areas are rapidly deteriorating. Existing drains have in many instances fallen into disrepair, whilst extensive areas within the cultivation zone, for example, Y Wenlli, capable of improvement, remain almost completely barren wastes.

Many of these wet wastes could be brought into useful cultivation by ordinary drainage methods. Failing such attempts, an arable break would in many cases arrest the deterioration of the herbage and the invasion of rushes.

The plant food status of these wet soils tends to be low. In particular, there appears to be widespread deficiency of phosphoric acid, and there is little doubt that most of these soils would benefit by dressings of basic slag or mineral phosphate. The potash content is fairly satisfactory. The figures for the lime content show wide variation, but indicate that treatment will soon be necessary for the maintenance of fertility.

Castleton Series.

Old Red Sandstone, varying in mode of occurrence, occurs in the soils covering an area of approximately one square mile. Only to the extent of a few acres does it constitute the sole parent material. More extensively it occurs as a variable constituent of mixed drift, in association mainly with Wenlock shale. In places it occurs only in the subsoil with a covering of other material.

The least contaminated Old Red Sandstone material is met

with in the form of drift skirting the lower slopes of a sharp limestone feature situated south west of Bryn Gwenallt near Abergele. The drift is bright reddish-brown in colour, of loamy texture, and gives rise to deep friable soil belonging to the Castleton Series. The satisfactory lime status of some of these soils may be attributed to a small complement of limestone material derived from the higher limestone slopes.

The plant food status of these soils appears to be low. They may be regarded, however, as soils of high potential fertility, and very suitable for horticulture.

The Frog Moor Series.

This series, derived from Old Red Sandstone drift, under conditions of impeded drainage, is represented by a small patch lying about half a mile east of Twynan Uchaf near Llysfaen. The profile consists of dull brown heavy silt loam overlying buff-brown impervious silt clay.

Series with Mixed Drifts.

As a constituent of mixed drift, Old Red Sandstone and Marl is conspicuous throughout an area extending approximately from Pen-y-dared to Cefn Castell and also in an area adjoining Bettws Lodge Wood. The varying proportions of this constituent result in a complexity of types. On the deeper freely drained drifts composed mainly of Red Sandstone we have about fourteen inches of slightly reddish-brown medium loam over orange-brown sandy loam. Another type, usually marked by impedance of the drainage, consists of greyish-brown heavy loam over reddish-brown clay formed mainly from sandstone weathering in situ.

On the adjoining limestone foot slopes we have deep reddish-brown soils derived from drift composed mainly of limestone residue with varying complement of red sandstone. These soils are very favourably situated and might be utilised for more specialised production.

Gower Series.

The soils derived from Carboniferous Limestone show considerable variation. The most significant variation pertains to profile depth and on this basis we may distinguish two broad types, a shallow facies occurring in the uplands and a deeper facies occurring on the lower slopes, and undulating low land.

The shallow soils are closely associated with the high limestone ridges which dominate most of the coastal region from the Great Orme to Abergele. The mode of occurrence varies largely

according to the contour. There are sedentary soils with characteristic transition through brashy subsoil to the parent rock. There are also thin soils lying abruptly on rock ledges without any apparent differentiation of horizons. In addition there are soils of greater depth occurring in drift pockets. Owing to shallowness and very free natural drainage, these soils as a whole are liable to severe seasonal drought, and their agricultural value is closely dependent upon the rainfall.

The lime status of these soils is generally, though not invariably, high, and it is to this we may attribute the closely grazed palatable herbage which is a striking feature not only of the enclosed cultivated portions but also of much of the open common-land. We would point out the contrast to this condition seen in the coarse heath vegetation usually found on the non-calcareous shale soils of similar situation.

Owing to their general affinities, these shallow soils have been indicated collectively on the map as the Gower Series.

Pentraeth Series.

The deeper limestone soils of the Pentraeth Series occur mainly on locally derived glacial drift. They include also colluvial soils of the steeper foot slopes. These soils are, essentially, brown or reddish-brown light to medium loams usually of deep tilth and well drained and comprise some of the best soils of the district. The lime status is on the whole satisfactory. Free calcium carbonate is not commonly present in the surface soil, but there is usually an adequate supply of lime in other forms. Occasionally we have met with soils on the lighter drifts, in which removal of lime by leaching has taken place to a marked degree, resulting in actual deficiency. Such cases are, however, uncommon. We have not sufficient analytical data to generalise upon the plant food status, though the figures available indicate rather low phosphoric acid content and deficiency of potash.

Flint Series.

Along the north of the area we have a group of soils derived from boulder clay of Triassic origin. This drift forms the level coastal strip extending from Llandulas to Abergele. East of Abergele it forms the extensive rolling slopes adjoining Morfa Rhuddlan. Remnants of this drift occur in various places along the north coast, and it is commonly met with in the lower layers of the soil profile on the low-lying portions of the Creuddyn Peninsula.

The derived soils belong to three series.

With satisfactory drainage we have the Flint Series. These soils are slightly reddish-brown medium to heavy loams with clay loam subsoils. A variant of this series formed on the coastal terrace west of Abergele is characterised by the ample depth of friable soils The smooth and almost level outline of the drift of this area appears to indicate that re-sorting of the surface material has taken place with removal of some of the finer material. At about two feet below the surface the subsoil is reddish-brown clay loam typical of the series.

Newport Series.

In the neighbourhood of Tan-y-dderwen a small feature of red sandy gravel gives rise to deep sandy loams of the Newport series. The profile throughout is of loose sandy texture.

Salop Series.

With impeded drainage we have soils belonging to the Salop series, which is the predominant series throughout the northern part of the Vale of Clwyd. These are brown medium to heavy loams of shallow tilth with dull reddish-brown heavy clay subsoil. Raw clay closely resembling unaltered parent material is usually reached within eighteen inches of the surface. In the wetter types, raw clay may lie within six inches of the surface.

The Salop soils were formerly wheat soils but are now mainly pasture, which is often of good quality and suited for dairying. Much of the dairy land of Cheshire belongs to this series.

With the exception of the freely drained soils of the Newport series, the Triassic soils have usually a good lime status. They are fairly uniformly responsive to phosphatic dressings and may be regarded as typical slag lands.

Alluvial Soils.

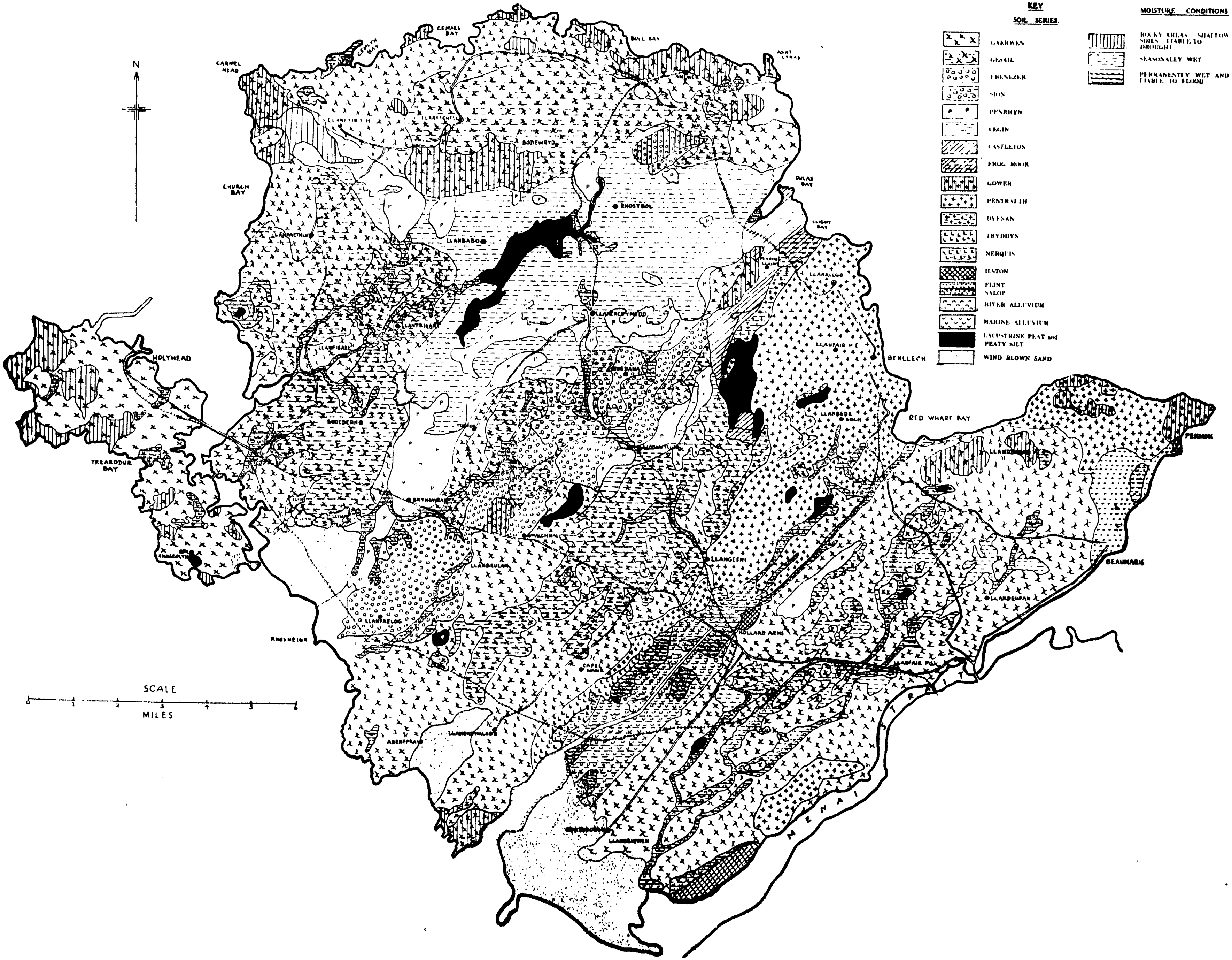
The principal areas of alluvial soils comprise a portion of the Rhuddlan Marsh adjoining Abergele, the marine flats of the Creuddyn Peninsula and the alluvium of the Conway valley north of Llanrwst. There are also numerous narrow stretches lying along the smaller rivers of the interior. The more extensive areas are those of the Elwy valley and the major tributaries, the Gallen and the Aled.

The marine soils may be divided into a number of textural types ranging from the stiff clay silt of Morfa Rhuddlan to marine-sorted sands associated with the dune features along the west of the Creuddyn Peninsula.

The soils of Morfa Rhuddlan are fairly uniform. The profile

FIG. II.

SOIL MAP OF ANGLESEY.



consists of greyish-brown clay silt with bluish-grey silt clay subsoil. Except for the presence of organic matter in the surface layer, there is little change of texture throughout the profile, which is very compact and impervious. The water table is normally high and during the winter months may occasionally rise to the surface. The lime and plant food status of these soils appears to be mainly good, but inadequate drainage limits their productive capacity. Arable cultivation is rarely practised and almost the entire area is under grass of fair quality with varying complement of rushes and sedges.

The soils of the Conway alluvial flat are predominantly fine silts with variable development of peat. As far inland as Trefriw the area is dominated by the effect of a high water table, the degree of impedance being closely reflected in the herbage type. The less impeded areas carry pastures with varying complement of rushes. On the wetter portions rushes are more numerous and in parts dominant. The worst conditions are seen in areas of reed swamp.

The alluvium associated with the smaller upland rivers, chief of which is the Elwy, is of the more friable texture and in the main are freely drained.

The soils belonging to the Conway series are typically shaly silt loams with coarse gravelly subsoils. Variation is chiefly in the depth of the loamy surface layer. Where the gravel lies near the surface, a condition which is seen in the Aled alluvium between Llansannan and Rhyd-yr-Arian and in parts of the Elwy alluvium between Llangernyw and Llanfairtalhaiarn, the soils are very liable to drought.

As a whole these soils appear to be of fair agricultural value and capable of high production with good treatment. Some of the pastures have high reputation for feeding quality.

Blown sand occurs as dune features along the west coast of the Creuddyn Peninsula and modifies the texture of soils of a considerable area inland.

In Table I are given typical analyses of the principal series encountered.

ANGLESEY.

Topography.

The topography of Anglesey (Fig. II) shows a marked contrast to that of Caernarvonshire. The highest points are Holyhead Mountain, 720 feet; Mynydd Bodafon, 588 feet; Mynydd Llwydiarth, Mynydd Parys, and Mynydd y Garn, each about 500 feet. In spite of the moderate height of its highest points, the surface of the island shows considerable diversity. In the

TABLE I.

Analytical Data for typical N.W. Denbighshire soils.

Series	*Powys.*	*Penrhyn.*	*Cegin.*	*Castleton.*	*Gower.*	*Pentraeth.*	*Marine Alluvium.*	*Conway.*
Locality	*Garthmyn Ganol, Llanrwst.*	*Sirior Hir, Abergele.*	*Llan-gernyw.*	*Bryn Heulog, Abergele.*	*Llysfaen.*	*Llysfaen.*	*Abergele.*	*Abbey, Llanrwst.*
Coarse sand	25.0	13.6	4.3	10.4	17.6	26.4	1.2	2.3
Fine sand	15.1	15.6	12.5	35.2	24.2	34.1	6.2	12.6
Silt	25.5	31.0	39.3	21.5	19.7	16.0	16.2	44.8
Clay	19.9	26.8	31.0	24.7	15.8	17.8	48.2	26.9
Organic matter	9.15	8.24	5.69	4.55	14.9	3.80	16.5	6.32
Available lime (CaO) ...	0.350	0.396	0.144	0.674	0.746	0.311	0.460	0.160
Available phosphate	0.013	0.006	0.031	0.007	0.010	0.014	0.031	0.018
Available potash	0.007	0.014	0.007	0.008	0.004	0.004	0.014	0.006

eastern part of the island there is a marked system of ridges and valleys running N.E. by S.W. West of the low-lying Malltraeth Marsh the topography is more confused and in some districts shows a " hummocky " type of relief.

The principal rivers run to the south-west; those running northwards being relatively unimportant. A striking feature of the island is the prevalence of " corsydd " or marshes, low-lying tracts with impeded drainage and, in some cases, peat formation. The largest of these tracts is Cors-y-Bol, near Llanerchymedd. Malltraeth or Cors Ddaugae is a tract of 4,000 acres reclaimed from the sea over a century ago.

Geology.

With the exception of small tracts of Trias covered by drift. the geology is all of Palaeozoic age. The most characteristic formation is the Mona Complex, a group of metamorphic rocks. schists, gneisses and quartzites, considered to be of Pre-Cambrian age. These rocks occupy the greater proportion of the surface area. Next in importance are the Ordovician rocks, sandstones and shales, occurring in the centre of the island. A small area of Old Red Sandstone runs S.W. from Dulas Bay. Carboniferous Limestone is well developed in the eastern part of the island, whilst Millstone Grit and Coal Measures are found in the Malltraeth area. A small tract of Upper Red Measures occurs opposite Caernarvon.

The whole of the area has been glaciated. The drifts are generally of local origin and even in the direction N.E.-S.W. there is no great carry-over of material from one formation to another. The soils are thus generally in close relation with the solid geology. An exception to this is in the Llangoed area, where the Ordovician rocks are completely masked by Carboniferous and Triassic drift.

Soil Series.

Owing to the diversity of rock formations, Anglesey provides a big variety of soil series. The system of classification has been outlined in a previous report. The main types recognised are tabulated below :

Parent Material.	*Series.*	*Types.*
Schists and Gneisses of the Mona Complex.	Anglesey. Gaerwen. Gesail. Braint.	Light loam. Light to medium loam. Medium to heavy loam. Silt, sandy silt.
Ordovician shale and Basement Beds (fine grits and conglomerate).	Powys. Penrhyn. Cegin. Conway.	Light to medium loam. Medium loam. Silty medium loam. Silty, medium loam. Sandy silt loam.
Carboniferous Limestone.	Gower. Pentraeth.	Light loam. Medium loam.
Carboniferous Limestone (nodular with shale bands)	Dyfnan.	Medium to heavy loam.
Coedana Granite.	Bangor. Ebenezer. Sion. Glanadda.	Light loam. Light loam. Light to medium loam. Silty loam.
Old Red Sandstone.	Monmouth. Castleton. Frog Moor.	Light loam. Light to medium loam. Medium to heavy loam.
Carboniferous Red Measures	Ilston.	Medium loam.
Millstone Grit.	Tryddyn. Nerquis.	Light to medium loam. Medium to heavy loam.
Triassic Marl.	Flint. Salop.	Medium to heavy loam. Medium to heavy loam.

Anglesey Series.

The Pre-Cambrian metamorphic rocks, consisting of some seventy different rock types, owing to their complicated nature have been termed the "Mona Complex." The schists and gneisses of the "Mona Complex" give rise to soil types peculiar to the island. The country occupied by these soils has an undulating topography, with occasional and often numerous rock outcrops. Between the rocky outcrops the soils are usually deep and of average fertility.

Soils of the Anglesey series are those derived in situ from the underlying rock. They are too confined in extent to be shown on a small scale map. The soils are brown light loams which pass fairly quickly to brashy subsoils lying on rock, which is generally encountered within a depth of twelve inches.

Gaerwen Series.

Soils derived under conditions of free drainage from Mona Complex drift material, which is invariably of local origin, belong

to the Gaerwen series. The top soils are reddish-brown light to medium loams of good depth and overlie yellowish-brown pebbly or stony light loam subsoils. When derived from the mica schists the soils are crowded with glistening mica fragments. From an agricultural standpoint this series provides easily worked soils of high potential fertility. A large number of analyses on samples of these soils indicate that generally the lime status is low and that they will respond to dressings of potassic and phosphatic fertilisers. There are a number of fatting pastures on this series. In the more sheltered regions these soils would appear to be well suited for horticultural production.

Gesail Series.

These soils are derived from the same parent material as those in the preceding series, but the drainage conditions show impedance. This gives the soils a brownish-grey appearance. The typical profile consists of about twelve inches of brownish-grey mottled medium to heavy loam over marbled yellow-brown and grey-brown compact slightly pebbly silty loam. The degree of drainage impedance varies considerably. In the better types there is practically no water-logging, whilst at the other extreme the soils are water-logged for considerable periods during the winter months, with consequent deterioration of the herbage. It will be seen from the accompanying map that this series is very prevalent throughout the island. The lime status varies considerably. Phosphate is frequently deficient, whilst potash is variable.

Although much of this series is of moderate fertility, there would obviously be improvement with adequate drainage. The Gesail A types—those soils lying on hill slopes and undulating ground—would lend themselves readily to improvement by systematic drainage schemes. The Gesail B types, occupying low-lying flat ground would present some difficulty in this respect.

Braint Series.

This series is made up of alluvial deposits from Mona Complex material. Typically the profile consists of brownish-grey silt overlying grey sandy silt. The few samples of this series analysed gave good lime figures with a satisfactory amount of potash, but were low in phosphate. The drainage is invariably sluggish, so much so that, generally speaking, the alluvium is permanently wet. There is no great continuous extent of the series. The distribution is fairly uniform throughout the island,

the usual occurrence being in long narrow strips running N.E.-S.W. The soils provide rushy, though useful, grazing.

Powys Series.

Soils derived from Ordovician shale and basement beds form a big block of country in the Llanerchymedd-Rhosybol district with an arm reaching south to Bryngwran and an offshoot running to Carmel Head.

The extent of the sedentary soils—the Powys series—is very small. It occurs as sporadic patches on elevated ground in the vicinities of Penymynydd, Llanerchymedd and Llanrhyddlad. The soils are brown light to medium loams of about eight inches depth overlying yellowish-brown fine shaly loam merging into disintegrating shale rock.

Penrhyn Series.

The freely drained soils derived from shale drift are of comparatively small extent. They are best seen near Llanerchymedd, Llanrhyddlad and Bryngwran. The top soils are dark brown or greyish-brown medium or silty medium loams, eight to twelve inches deep overlying pale yellowish-brown shale silty loam subsoils. This series lends itself readily to cultivation and fertility is moderately high. Analytical data show a considerable variation in content of plant nutrients. Figures for phosphate are generally poor, particularly in the case of old grassland.

Cegin Series.

The drift-derived soils characterised by impeded drainage and constituting the Cegin series, form the great majority of the shale soils in Anglesey. The drainage conditions vary considerably from the state resulting in occasional rushes and sedges in the pasture herbage and a slight mottling of the soil to an impeded condition causing permanent wetness. In general, these soils are only seasonally wet and are useful agricultural types. The usual profile consists of about nine inches brownish-grey mottled silty medium loam over brownish-grey or yellowish-grey heavily mottled silty medium to heavy loam. The colour becomes more variegated and the texture heavier with increasing depth to about two feet, with a change then to marbled greyish and yellowish-grey shale clay.

The Cegin A soils—those with a sloping or undulating topography—could readily be drained. The Llanerchymedd-Rhosybol district would be suitable for a drainage scheme as there are large continued areas of this type. The Cegin B soils

belonging to the hollows or low-lying flat land are of very limited extent and taking the area as a whole, unimportant. Generally speaking the lime figures for these soils were good whilst the potash and phosphate figures were rather low.

Conway Series.

There are occasional small patches of alluvium derived from shale, giving rise to the Conway series. They are greyish-brown sandy silt loams and provide fairly good grazing between the rushy patches.

Gower Series.

There is a strip of Carboniferous Limestone running from Penmon to Llanfihangel and a large elevated area from Lligwy to Llangefni and continuing as a thin strip along the north side of Malltraeth Marsh. It outcrops again along the southern end of the Menai Strait. The Carboniferous Limestone, as well as the associated basement material, has given rise to soils belonging to the Gower and Pentraeth series. There is only a narrow band of these soils running parallel with the Strait, most of the limestone in this locality being covered by a mantle of Mona Complex drift.

There are considerable areas in the Marian Glas—Benllech district and also at Penmon of thin soil on rock with numerous bare patches. Within these areas are occasional sedentary profiles of the Gower series. These soils are reddish-brown stony light loams of shallow depth. They support rich sweet herbage but are too freely drained and consequently are prone to suffer from drought.

Pentraeth Series.

The freely-drained Carboniferous Limestone drift soils make up the Pentraeth series. These soils are probably the most fertile in Anglesey. The warm brown medium loam top soils vary in depth but are usually deep—about twelve inches—the subsoils having a ruddier colour and similar texture. In the Llangoed district the soils are occasionally of a light sandy texture which suggests contamination with Triassic sand. The Pentraeth soils are of very high fertility. In this connexion it may be noted that during 1928-29 typical pastures from fourteen centres in Great Britain were periodically sampled and analysed —one of the centres being on the Pentraeth series in Anglesey. This Anglesey pasture on both occasions gave the highest dry matter yield. It is not suggested that in virtue of this figure

the Anglesey plot was the best pasture, but from reputation it is undoubtedly of high merit. The Pentraeth soils are usually well supplied with lime but do not invariably contain free calcium carbonate. Indeed, the fact is, that in quite a number of cases benefit would result from dressings of lime. This is because soils of this series are often very freely-drained and the original lime is gradually lost in the drainage water. From a number of samples analysed it appears that these soils are usually well supplied with lime, the potash status being very variable, and the phosphate figures generally low.

Dyfnan Series.

This is a local series mapped in the Cefniwrch-Llandyfnan neighbourhood. The parent material is a nodular limestone with rapidly alternating bands of shale. The local boulder clay derived from this parent material is of a stiff and rather impervious nature, the high clay content being accounted for by the shale bands in the parent rock. The soil profile consists of about nine inches of yellowish-brown mottled, medium to heavy loam, overlying light yellowish-brown clay loam.

Bangor Series.

A strip of Coedana granite runs across the middle of the island from Llanfaelog almost to Llanfihangel-Tre'r Beirdd and gives rise to sedentary and drift-derived soils. The area over which they occur is in general of a rocky, broken and irregular outline, and the depth of drift varies considerably. The extent of the sedentary soils of the granite is small and is confined to occasional patches on rocky high ground. The rock weathers to a brown stony-light loam of shallow depth merging into rocky brash.

Ebenezer Series.

This series is made up of soils of free drainage derived from granite drift. The following is a typical profile—about eight inches of brown stony light loam over yellowish to orange-brown fine stony sandy loam and below about twenty inches pale or greyish-yellowish brown stony pebbly light loam. The subsoil colour is characteristic of the Coedana granite soils. This series provides free working soils, generally of average fertility. There are occasional fatting pastures on these soils. Samples analysed were well supplied with lime, not very deficient in potash, but definitely deficient in phosphate. The Ebenezer soils have close affinities with the soils of the Gaerwen series and for most purposes could be grouped with them.

Sion Series.

Soils of this series are derived from granite drift under impeded drainage conditions. There is a considerable area of these soils in the neighbourhood of Llynfaes and Coedana. The profile in general shows about twelve inches of greyish-brown mottled light to medium loam over yellowish to orange-brown light to medium loam. The Sion series are almost indistinguishable from the Gesail series.

Glanadda Series.

The small patches of alluvium within the Coedana granite area belong to the Glanadda series. Of small extent, the series is unimportant.

Monmouth Series.

The Old Red Sandstone forms a ridge running from Dulas Bay to Capel Coch and appears again farther south adjoining Cors Erddreiniog. A characteristic of this Old Red Sandstone is the presence of small irregularly oval concretions of calcite. The weathered rock often has a vesicular appearance—the calcite having weathered away, with consequent enrichment of the soil in lime.

A small part of the northern end of Bodafon Mountain has patches of sedentary soil of the Monmouth Series. The soil is shallow and its extent renders it unimportant agriculturally.

Castleton Series.

This series is composed of soils derived from Old Red Sandstone drift under conditions of free drainage. The soils are normally moderately deep light to medium loams of a slightly purplish reddish-brown colour. The subsoils are a deeper colour and of a gritty pebbly or stony light to medium loam texture. In general these soils are put under a short rotation and are considered to be of high fertility. A number of samples analysed gave varying results but usually the figures for lime and potash were good, while phosphate was often rather low.

Frog Moor Series.

The Frog Moor Series is the drift phase of the Old Red Sandstone with impeded draiuage. The soils support rushy pastures of moderate fertility. Small in extent the series is not important.

Ilston Series.

Bordering the Strait and opposite Caernarvon lies a comparatively small strip of Carboniferous Red Measures. Another

TABLE II.

Analytical data for typical Anglesey soils.

Series .... *Locality* ...	*Gaerwen.* *Bodorgan.*	*Gesail.* *Rhosbeirio.*	*Penrhyn.* *Llanfflewin.*	*Cegin.* *Llantrisant.*	*Pentraeth.* *Llanbedr-Goch.*	*Ebenezer.* *Llanfaelog.*	*Castleton.* *Maenaddwyn.*
Coarse sand ...	15.1	9.4	15.7	11.7	8.9	25.3	12.9
Fine sand	31.8	24.8	19.6	17.2	36.5	35.6	33.7
Silt	20.5	35.0	21.8	26.7	22.6	16.3	20.3
Clay . .	20.9	19.2	25.7	29.9	21.1	14.0	19.1
Organic matter ...	5.16	5.22	7.07	6.32	4.27	4.18	7.31
Available lime (CaO) ..	0.199	0.224	0.134	0.356	0.230	0.146	0.236
Available phosphate	0.007	0.008	0.028	0.010	0.007	0.013	0.018
Available potash ...	0.008	0.008	0.007	0.006	0.006	0.008	0.015

small outcrop lies close to Llanfihangel-Esgeifiog. In this latter district we have an example of the pure Red Measures drift, but in the former area there is a certain amount of contamination with schistose drift.

The well-drained drift-derived soils belong to the Ilston series. They are deep bright reddish-brown medium loams, almost stoneless. The subsoils have a more subdued colour and medium loam texture.

Millstone Grit Soils.

Adjoining Malltraeth Marsh a comparatively small area of Millstone Grit has given rise to soils of the Tryddyn and Nerquis Series. Owing to the high percentage of silica in the parent rock the soils are by nature poor in plant nutrients. Drift-derived soils of the freely-drained and impeded drainage types have been mapped, but their extent is relatively small.

Trias Soils.

The northern ice-sheet deposited a mantle of Triassic drift extending from Llangoed to Beaumaris from which have developed soils of the Salop and Flint series. The well-drained boulder clay types fall into the Flint series, the impeded drainage types into the Salop series. These soils resemble in every respect those similarly classified in Flintshire and described in the last report.

Mixed Drifts.

There are certain small areas of soils derived from drift of mixed origin. Lack of space precludes a detailed description of these and other relatively unimportant series which have been mapped on the six-inch scale.

Blown Sand.

The blown sand of the south west coastline is of little agricultural value. In passing it may be noted that near Newborough a depth of sand covers soils which at one time were under cultivation.

Marshes.

The marshes of Anglesey under present conditions are of no great agricultural importance. With the exception of Malltraeth they are lacustrine deposits and under conditions of impeded drainage have usually developed a good depth of peat.

Malltraeth is a tract of land of about 4,000 acres which has been reclaimed from the sea. At the present time little of the marsh is under cultivation. Most of the cultivated land is towards the seaward end. A bigger portion of the marsh was formally under cultivation but under present conditions unsatisfactory drainage constitutes an obstacle to better utilisation of the land.

The soils are generally of a sandy or silty nature, as might be expected from marine alluvium. There is a comparatively small area of peat. Throughout the marsh the soils show a deficiency of lime.

In Table II are given typical analyses.

Conclusion.

The soil survey of Wales has now been in progress for nearly ten years. The area mapped is mainly in N. Wales and certain general conclusions may now be drawn.

The most striking feature is the extent of soil types suffering, to a greater or less degree, from impeded drainage. Where this impedance has been dealt with by means of drainage, soils of considerable fertility result. In fact, some of the most productive soils are of this class. There are, however, large areas where no improvement has been attempted or where drainage systems have fallen into dis-repair. There seems no doubt that the area of rush infestation in pastures has increased considerably during recent years, partly through neglect of drainage.

The same impression of neglect and retrogression is gleaned from the laboratory examination of soils encountered in the soil survey and in general advisory work. The majority of the soils examined suffer from deficiency of lime and it is certain that unless calcareous dressings are given, the area of sour land will increase, with consequent depression of fertility. N. Welsh soils have, as a rule, no natural reserves of calcium carbonate, and present day farmers have been drawing on the dwindling residues of dressings given in past generations.

Phosphorus deficiency is also widespread, particularly in old grazings, and remedial dressings are urgently required over large areas. The need for potash undoubtedly exists in many cases, but is not always so evident.

These conclusions as to the widespread need for more attention to manurial dressings are based mainly on experience in N. Wales, but it is highly probable that they apply also to other parts of Wales. Such samples as have been obtained from other parts of the country, notably Glamorganshire, certainly bear out these views.

GRADING MILK AT THE FACTORY.

A CONSIDERATION OF THE VALUE OF THE METHYLENE BLUE REDUCTASE TEST AND THE FERMENTATION TEST.

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The grading of raw milk at the more progressive Milk Factories of this country is commonly carried out by the application of one or more bacteriological tests, namely, plate count, coliform organisms test, direct microscopic examination, and the methylene blue reductase test.

Where bacteriological control has been in use for some time and fairly "low count" milk is supplied by the farmers throughout the season, the plate count method used alone or with the coliform organisms test forms the most successful basis for any system of payment for milk according to hygienic quality. However, the introduction of a grading system at a factory may be carried out by simpler and less expensive methods which will serve to eliminate unsatisfactory milk supplies.

The Methylene Blue Reductase test has been suggested as being eminently suitable for eliminating milk which is so poor in quality that it would be unsuitable for pasteurising or manufacturing purposes. This test is cheap, simple in operation and quickly carried out. Samples of milk are taken on the factory receiving stage, and a definite quantity of each (10 ml., 20 ml., or 40 ml.) placed in sterile test-tubes.

In the work reported in this paper 40 ml. of milk were used, and 1 ml. of a solution of methylene blue was added, this being of such a strength that the final dilution of the dye in the milk was 1/200,000. The solution was prepared by dissolving one Blauenfeldt and Tvede methylene blue tablet in 200 ml. of boiled water. During later work 20 ml. of milk have been used in 6 ins. by 5/8th in. test tubes and 0.5 ml. methylene blue solution added. The tubes are fitted with an india-rubber bung and the mixture of milk and dye mixed by inversion. The samples are then kept in the water bath at a constant temperature of 38°—40°C. (100 —104 F.), and the time taken for the disappearance of the blue colour noted.

This test is based upon the fact first noticed by Duclaux

(1887), that cow's milk has the power of converting certain colouring matters such as indigo-carmine into the corresponding leuco-compound by reduction. He also showed that this property of milk depends upon the micro-organisms which it contains. Neisser and Wechsberg (1900) proposed the use of methylene blue solution as a means of judging the quality of milk. The application of the test as used at present was worked out by Barthel and Orla-Jensen (1912). They suggest that the milk may be graded into four classes, as follows :—

			Reduction time.
Grade I.	Good Milk	—	5½ hours (or more)
Grade II.	Fair average quality ..	—	2 to 2½ hours.
Grade III.	Bad milk	—	20 mins. to 2 hours.
Grade IV.	Very bad milk	—	20 mins. (or less).

Gillespie (1920) was the first to show that the reducing tendency of bacteria can be measured by means of the potentiometer, and Clark (1928) applied the method to a study of milk samples.

Different species of bacteria vary in their capacity to reduce methylene blue. The work of Fred (1912), Rahn (1920), Hastings, Davenport and Wright (1922), Clark (1928), Thornton and Hastings (1929) and Frazier and Whittier (1931) has shown that at 38°—40°C. the lactic acid streptococci and organisms of the coliform group are the most rapid reducers. Thus the reductase test is to a certain extent a measure of the associated activity of the bacterial flora of milk. Any attempt to obtain evidence of correlation between the results of the Reductase test and plate counts is unsatisfactory, as the two tests record different things. The principles concerned in the reaction together with considerations of the practical value of the test have been recently reviewed by Mattick (1930), Whitehead (1930), and Mattick, Hiscox and Christian (1933).

The experimental work outlined in this paper was carried out at three milk plants and a group of five farms.

Plant A.

Over 4,000 gallons of milk is received from 90 suppliers daily and pasteurised. The milk of each producer was examined at monthly intervals by means of plate count, coliform organisms test, methylene blue reductase test and fermentation test. Over 3,500 samples were tested during the course of two years. Bacteriological control work had been in operation at this plant for some years, consequently the hygienic quality of the supplies was particularly good.

Plant B.

The milk supplied by approximately 60 farms was examined by means of the plate count, coliform organisms test, reductase and fermentation tests. Results for the Summer of 1932 only are given. This period coincided with the introduction of bacteriological control work at the plant. The bulk of the milk was sterilised, a small portion being pasteurised.

Plant C.

The milk supplied by 114 farms was examined by means of the reductase and fermentation tests only, during particularly warm periods—August and September, 1928 and 1932. No bacteriological control work had been previously carried out at this factory. The bulk of the milk was pasteurised, any surplus to liquid milk requirements being converted into Cheshire Cheese.

Group of five farms.

In order to obtain a standard of comparison the milk supplies of five farms, known to produce milk of particularly good quality, was graded at fortnightly intervals during two years (1932-1934). Over 75% of the 270 samples examined attained "Certified" bacteriological standards.

Reductase Test.

The published results on the use of the reductase test for the grading of market milk in this country are very few, since the plate count method is considered more satisfactory. The former has been used in some cases as a supplementary test. Grimes (1928) during the course of three years examined 867 samples for bacterial count (plate method) and by means of the reductase test. The samples were not cooled or treated in any way and the majority were examined within a period of three to eight hours after milking. His results are as follows :—

TABLE I.

	No. of samples.	*Per cent.*
Grade I.	511	59
Grade II.	261	30
Grade III	59	7
Grade IV.	36	4
Total	867	100

Barkworth (1929) examined 281 samples of afternoon milk from 100 farms. All the samples were about 18 hours old on testing at the advisory laboratory. The period of testing extended from April, 1926, to November, 1927, thus embracing all seasons, and including an especially hot spell in the Summer of 1926.

TABLE II.

		No. of samples.		*Per cent.*
Grade I.	....	96	....	42
Grade II.	....	52	....	22
Grade III.	....	56	....	24
Grade IV.	....	27	....	12
Total	....	231	....	100

Hiscox, Hunt and Catherwood (1930) carried out a number of reductase tests on milk supplied by twelve selected farms, at a large London depot. Weekly samples (morning's and evening's milk alternately) were tested over a period of 15 months. No previous bacteriological control had been exercised from the factory in the case of these farms. The 224 samples of morning's milk were tested on arrival at the factory 6—7 hours after milking. The evening's milk was tested on arrival at 19—20 hours old.

TABLE III.

Reductase test.	*Morning's Milk.*		*Evening's Milk.*	
	No. of samples.	*Per cent.*	*No. of samples.*	*Per cent.*
Grade I.	216	96	189	82
Grade II.	6	3	25	11
Grade III.	2	1	17	7
Grade IV.	0	0	0	0
Total	224	100	231	100

They point out that for milk of this type, which may be assumed to be of fair average quality, the reductase test is not sufficiently delicate to allow of any real differentiation. This is particularly true of morning's milk tested within 6—7 hours of milking. During the winter months (end of October to end of April) only a very occasional sample was placed in Grade II. During the summer months a fair number of samples were placed in Grades II and III and the test then allowed of a certain

amount of differentiation. These investigators thus concluded that the usefulness of the reductase test as a means of differeniating between milk supplies arriving at a factory is apt to be limited to the warmer months of the year.

The results obtained during the course of the present investigation have been grouped according to season. Samples taken during the " winter months " (October to April) form the first group, whilst the second group includes all samples taken during the warmer months (May to September).

Plant A " Winter months " (October-April).

The results of the examination at 16—18 hours of 1,176 samples by means of the plate count on standard agar and coliform organisms test are given in Tables IV and V. These results show that the milk received during the colder months was of a particularly good quality, 86 per cent. of the samples giving plate counts under 30,000 per ml.

TABLE IV.

Plate counts on Standard Agar at 16-18 hours.

Bacterial Count Groups.	Number of Samples in Various Count Groups.							
	Oct.	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*March.*	*April.*	*Total.*
0–5,000	12	35	66	84	75	60	54	386
5,0001–10,000	23	62	46	47	42	44	47	311
10,0001–30,000	71	57	40	21	40	40	43	312
30,001–200,000	66	17	15	16	12	19	19	164
200,001–500,000	—	—	1	—	—	1	1	3
Over 500,000	—	—	—	—	—	—	—	—
Total	172	171	168	168	169	164	164	1,176

TABLE V.

Samples attaining various bacteriological standards on plate count and coliform organisms content.

Standard.	*Maximum plate count per ml.*	*Maximum B. coli content.*	*No. of Samples.*	*Per cent.*
"Certified"	30,000	+1 ml.	913	77.6
"Grade A"	200,000	+ 1/10 ml.	1.106	94.0
Under "Grade A"			70	6.0

The reductase test results for this period are given in Table VI. Very few samples are placed in Grades III and IV, even when evening's milk is tested at 16—18 hours after milking. It is significant to note that they agree very closely with the results obtained by Hiscock, Hunt and Catherwood.

TABLE VI.

Reductase grade.	Morning samples examined 4-7 hours after milking.		Evening samples examined 16-18 hours after milking.		Mixed a.m. and p.m. samples. Maximum age 18 hours.		Totals.	
	No.	%	No.	%	No.	%	No.	%
Grade I.	520	96.1	919	89.6	236	94.0	1,675	92.1
Grade II.	18	3.3	95	9.3	14	5.6	127	7.0
Grade III.	3	0.6	10	1.0	1	0.4	14	0.8
Grade IV.	0	0	2	0.1	0	0	2	0.1
Totals	541		1,026		251		1,818	

Plant A, " Summer months " (May-September).

The plate count and coliform test results for this period are given in Tables VII and VIII. The milk received during this period is of a good average quality, 86 per cent. of the samples examined attaining Grade A standards. Actually 58 per cent. of the samples had plate counts under 30,000 per ml.

TABLE VII.

Plate counts on Standard Agar.

Bacterial Count Groups.	Number of Samples in Various Count Groups.					
	May.	*June.*	*July.*	*August.*	*September.*	*Total Samples.*
0–5,000	44	32	11	23	21	131
5,001–10,000	36	21	21	18	30	126
10,001–30,000	36	47	44	41	56	224
30,001–200,000	46	63	85	85	64	343
200,001–500,000	2	2	6	1	1	12
Over 500,000	—	—	—	—	—	1
Total Samples	165	165	167	168	172	837

TABLE VIII.

Samples attaining various Bacteriological Standards.

		No. of samples.		Per cent.
" Certified "	....	423	.. .	50.5
" Grade A "	....	722	....	86.1
Under " Grade A "	....	115	....	18.9

The reductase test results are given below. Samples examined at 16—18 hours after milking are well differentiated. It is evident that the grading of samples over 16 hours old can be usefully carried out during May to September by means of the reductase test.

TABLE IX.

Reductase Grade.	*Morning samples examined 4-7 hours after milking.* No.	%	*Evening samples examined 16-18 hours after milking.* No.	%	*Mixed a.m. and p.m. samples. Maximum age 18 hours.* No.	%	*Totals.* No.	%
Grade I	617	87.2	462	60.0	129	59.7	1,208	69.2
Grade II	113	14.7	184	23.9	51	23.6	348	19.9
Grade III	26	3.4	90	11.7	26	12.0	142	8.1
Grade IV	4	0.7	34	4.4	10	4.7	48	2.7
Total	760		770		216		1,746	

Plant B.

Samples were examined at this factory during the warmer months of May to September. The hygienic quality of the milk was much poorer than that supplied to Plant A, as the following results demonstrate.

TABLE X.

Samples attaining various standards on plate count and coliform tests.

	No. of samples.	*Per cent.*
" Certified "	7	5.8
" Grade A "	22	18.3
Under " Grade A "	98	81.7
	120	100

TABLE XI.

Reductase grade.	*Morning samples examined 28 hours after after milking.* No.	%	*Evening samples examined 16-18 hours after after milking.* No.	%	*Total samples.* No.	%
Grade I	140	41	164	56	304	48
Grade II	77	22	65	22	142	22
Grade III	81	24	46	16	127	20
Grade IV	46	13	17	6	63	10
Total	334		292		636	

Morning samples in this case were examined at 28 hours after milking. This serves to differentiate the supplies into different grades, and in this factory these supplies were not sterilised or pasteurised until this age. The results for the samples tested at 16—18 hours old showed some agreement with the similar group for Plant A, although the plate count results

show that the milk supplied to this factory was of a much poorer quality. This illustrates the limitations of the reductase test.

Plant C.

Samples were tested at this factory during particularly warm weather in August and September. The milk was brought in by the farmers and the temperature of the majority of supplies on sampling at the receiving stand was between 65° and 70°F. A few dozen samples were taken at this time and sent to the advisory laboratory for bacteriological examination at 28 hours after milking. Most of these samples gave plate counts over 500,000 and coliform organisms in 1/1000 ml. The reductase test results are given in Table XII. It was possible to eliminate milk of poor quality by means of the test at this plant. Further samples were taken from suppliers which were placed in Grade IV, and their milk was continually graded low. Further examination of the low grade milk by means of the plate count method, demonstrated the presence of excessive numbers of bacteria.

TABLE XII.

Reductase grade.	*Morning samples examined 4-7 hours after milking.* No.	%	*Evening samples examined 16-18 hours after milking.* No.	%	*Mixed a.m. and p.m. samples. Maximum age 18 hours.* No.	%	*Totals.* No.	%
Grade I	92	54	8	17.5	5	21	105	44
Grade II	10	23	18	39.0	5	21	63	26
Grade III	28	17	12	26.0	11	46	51	21
Grade IV	10	6	8	17.5	3	12	21	9
Totals	170		46		24		240	

Farms Producing Low Count Milk.

The five farms included in this group produced milk which attained " Certified " bacteriological standard throughout the winter and spring months. An occasional sample failed to attain this standard during the warmest periods. The reductase test results for 270 evening milk samples taken at fortnightly intervals and examined at 16—18 hours after milking are given below. These results agree on the whole with the plate count and coliform tests. Only 20 samples (7 per cent.) failed to attain Reductase Grade I. The majority of these were summer samples. The reductase test is not sensitive enough for grading milk of this quality, 250 of the samples being placed in the same

grade, whereas the plate counts of these samples varied from 100 to 100,000 colonies per ml. Evening samples taken at Plant A during the winter months show reductase results very similar to those given below.

TABLE XIII.

Reductase test.	*Number of samples.*	*Per cent.*
Grade I.	250	92.6
Grade II.	17	6.3
Grade III	3	1.1
Grade IV.	0	0

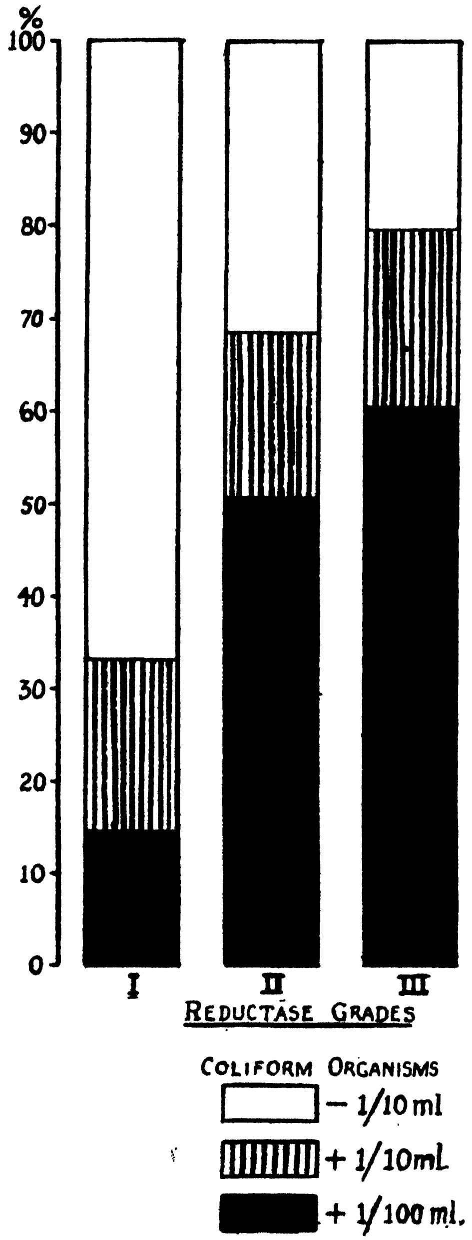
A survey of the results obtained at the factories and farms demonstrates that the reductase test can be usefully employed for the preliminary grading of milk, particularly during the warmer months. When a system of grading combined with advisory work on the farms has been in operation for a few years the test is not sensitive enough for bacteriological control. Where systems of bonus payments for " low count milk " have been introduced in this country, it has been generally found that over 80 per cent. of the producers attain the Grade A bacteriological standard within twelve months or so of the introduction of the scheme. Hiscox and Starling (1925) carried out a series of comparative tests, using the plate count in conjunction with determinations of coliform organisms content, and they conclude that the reductase test is not sufficiently reliable to be used in substitution for the plate count for grading milk supplies of low bacterial content. It is not advisable, therefore, to use the reductase test alone as a basis for bonus payments for good quality milk, or for purposes of advisory work in connection with clean milk production. During the course of the present investigation it was found that the test can serve a useful purpose as a supplementary method of grading in conjunction with plate count and coliform tests.

Comparison of Reductase Test and Coliform Test.

In Chart I and Table XIV a comparison has been made between these two systems of grading. It would appear that the two tests show some general correlation. A high percentage of the samples placed in Reductase Grades III and IV show the presence of large numbers of coliform organisms, whilst they were not detected (in 1/10 ml.) in 67 per cent. of 1,088 samples placed in Grade I.

CHART I.

Comparison of Reductase Test and Coliform Test.



If the presence of large numbers of coliform organisms as determined by the presumptive test is to be taken as an indication of poor hygienic quality in milk, the reductase test does

not seem to be sensitive enough for grading purposes. It will be seen that coliform organisms were detected in large numbers (+ 1/100 ml.) in 868 samples. According to the bacteriological

TABLE XIV.

Coliform Organisms.	Reductase Grades.								Total Number of Samples.
	I.		II.		III.		IV.		
	No.	%	No.	%	No.	%	No.	%	
Absent in 1/10 ml. ..	727	66.8	70	31.2	21	20.2	4	11.1	822
Present in 1/10 ml. ...	199	18.3	40	17.9	20	19.2	3	8.3	262
Present in 1/100 ml . .	162	14.9	114	50.9	63	60.6	29	80.6	368
	1,088		224		104		36		1,452

standards of the Milk (Special Designations) Order this group of samples would fail to attain Grade A standards, but they were graded as follows by the reductase test :—

Grade I.	....	162 samples	....	44%
Grade II.	....	114 samples	....	31%
Grade III.	....	68 samples	....	17%
Grade IV.	....	29 samples	....	8%

Thus nearly half were placed in Grade I and only 25% in Grades III and IV.

On the other hand coliform organisms were not detected in 1/10 ml. of milk in 822 samples. This group on the presumptive coliform test alone would satisfy the English requirements for Certified milk. Grading by means of the reductase test shows a close correlation in this case, 88 per cent. of the samples being placed in Grade I, 9 per cent. in Grade II, and only 8 per cent. in Grade III and IV. These results, therefore, indicate that although some general correlation may be observed when a large series of samples graded by the two tests are compared, a detailed examination of the data shows that the reductase test is not a reliable indication of the hygienic quality of milk which contains large numbers of coliform bacteria.

Fermentation Test.

The tubes of milk used for the reductase test are kept in the water bath at 38°—40°C. for 24 hours when the type of fermentation is observed. Five types are generally distinguished (Orla-Jensen, 1931).

1. Fluid .... coagulation not yet taken place.
2. Uniform, gelatinous curd .... true lactic acid bacteria predominate.
3. Blown or gassy curd .... indicating the presence of coliform and other gas-producing organ-

4. Spongy or granular curd .... milk containing relatively few true lactic acid bacteria at commencement of fermentation - gas production taking place before coagulation.

5. Cheesy or peptonized curd .... distinguished by a well-marked separation of clear whey, due to organisms which secrete rennet—like enzymes.

The fermentation test was carried out at the three milk factories with the following results:—

TABLE XV. (Plant A).

Class.	Fermentation	*Winter months. Oct.—Apr.* No.	%	*Warmer months May -Sept.* No.	%	*Total samples.* No.	%
1.	Fluid	124	6.8	77	4.4	201	5.6
2.	Gelatinous	1,172	64.7	945	54.2	2,117	59.7
3.	Blown	258	14.2	291	16.7	549	15.4
4.	Spongy	180	10.0	312	17.8	492	13.9
5.	Cheesy	77	4.3	119	6.9	196	5.4
Total samples.		1,811		1,744		3,555	

TABLE XVI. (Plant B).

Class.	Fermentation	*Morning samples. (28 hours).* No.	%	*Evening samples. (16-18 hours).* No.	%	*(Warmer months). Total samples.* No.	%
1 and 2	Fluid or Gelatinous	88	45	90	51	178	48
3.	Blown	18	9	14	9	32	9
4.	Spongy	34	17	17	10	51	14
5.	Cheesy	56	29	54	30	110	29
Total samples.		196		175		871	

TABLE XVII. (Plant C).

Class.	Fermentation.	*Morning Samples.* 4-7 *hours.* No.	per cent.	*Evening Samples.* 16–18 *hours.* No.	per cent.	*Mixed a.m. and p.m. Samples. Maximum age* 18 *hours.* No.	per cent.	*Total Samples.* No.	per cent.
1 and 2	Fluid or Gelatinous	70	41	12	26	9	38	91	38
3.	Blown	24	14	4	9	2	8	30	12
4.	Spongy	52	31	10	22	2	8	64	27
5.	Cheesy	24	14	20	43	11	46	55	23
Total Samples		170		46		24		240	

The fermentation test is intended to show whether the milk has become infected with an undue proportion of gas-producing bacteria. Though lactose-fermenting yeasts may sometimes be found in milk, the Coliform bacteria are generally the most prevalent gas forming organisms, particularly in raw milk. The test should, therefore, indicate undue contamination during production or inefficient sterilisation of utensils. A comparison of the above fermentation test results and the reductase results shows very little correlation. If the development of Blown or Spongy curds is taken as an indication of heavy contamination it would be assumed that the milk supplied to Plant A is worse than that supplied to Plant B. If the relative numbers of samples developing a cheesy (peptonised) curd are considered, it will be seen that only 7 per cent. of the samples tested during the warm period at Plant A are placed in this group, as compared with 29 per cent. at Plant B and 28 per cent. at Plant C.

A direct comparison of the two tests is given in the following tables :—

TABLE XVIII.

Class.	*Fermentation.*	Per Cent. Samples in Various Reductase Grades.				*Total Samples.*
		I.	*II.*	*III.*	*IV.*	
1.	Fluid	7	1	0	9	201
2.	Gelatinous ...	63	43	46	68	2,117
3.	Blown	12	30	27	17	549
4.	Spongy	13	19	15	9	492
5.	Cheesy.......	5	7	12	6	196
		100	100	100	100	3,555

TABLE XIX.

Reductase Grades.	Per Cent. Samples in Various Fermentation Classes.					*No. of Samples.*
	1 *Fluid.*	2 *Gelatinous.*	3 *Blown.*	4 *Spongy.*	5 *Cheesy.*	
I.	97	85	65	76	70	2,874
II.	3	9	25	18	17	459
III.	0	4	9	5	11	175
IV.	0	2	1	1	2	47
	100	100	100	100	100	8,555

When it is considered that the reductase test results are an index of bacterial action within the first few hours of incubation and the fermentation results are (except in Class I) an indication of the end point of competing bacterial action, it is not surprising to find hardly any actual correlation in the respective grading. The majority of the samples still fluid after

24 hours incubation have not reduced methylene blue in 5½ hours; this is the only correlation that can be observed.

TABLE XX.

Presumptive coliform test.		Fermentation Test.					
Coliform organisms.	Number of samples.	Blown curd.		Spongy curd.		Total samples. Blown and Spongy.	
		No.	Per cent.	No.	Per cent.	No.	Per cent.
Absent in 1/10 ml.	840	126	15	84	10	210	25
Present in 1/10 ml.	256	73	29	29	11	102	40
Present in 1/100 ml.	352	80	23	38	11	118	34

TABLE XXI.

Coliform organisms.	Fermentation test.										Total Number of Samples.
	I. Fluid.		II. Gelatinous.		III. Blown.		IV. Spongy.		V. Cheesy.		
	No.	%	No.	%	No.	%	No.	%	No.	%	
Absent in 1/10 ml.	36	84	549	62	126	45	84	56	45	52	840
Present in 1/10 ml.	5	12	136	15	73	26	29	19	13	15	256
Present in 1/100 ml.	2	4	203	23	80	29	38	25	29	33	352
Total samples ...	43		888		279		151		87		1,448

Comparison of Fermentation Test and Coliform Test.

Although the temperature of incubation during the fermentation test is at the optimum for the development of coliform organisms (particularly the Bacterium coli group) they are often

inhibited by the presence of a large mixed flora. A comparison with presumptive coliform test results shows that the presence of large numbers of coliform bacteria (+ 1/100 ml.) does not always result in a blown or spongy curd. From data given in

CHART II.

Comparison of Fermentation Test and Coliform Test.

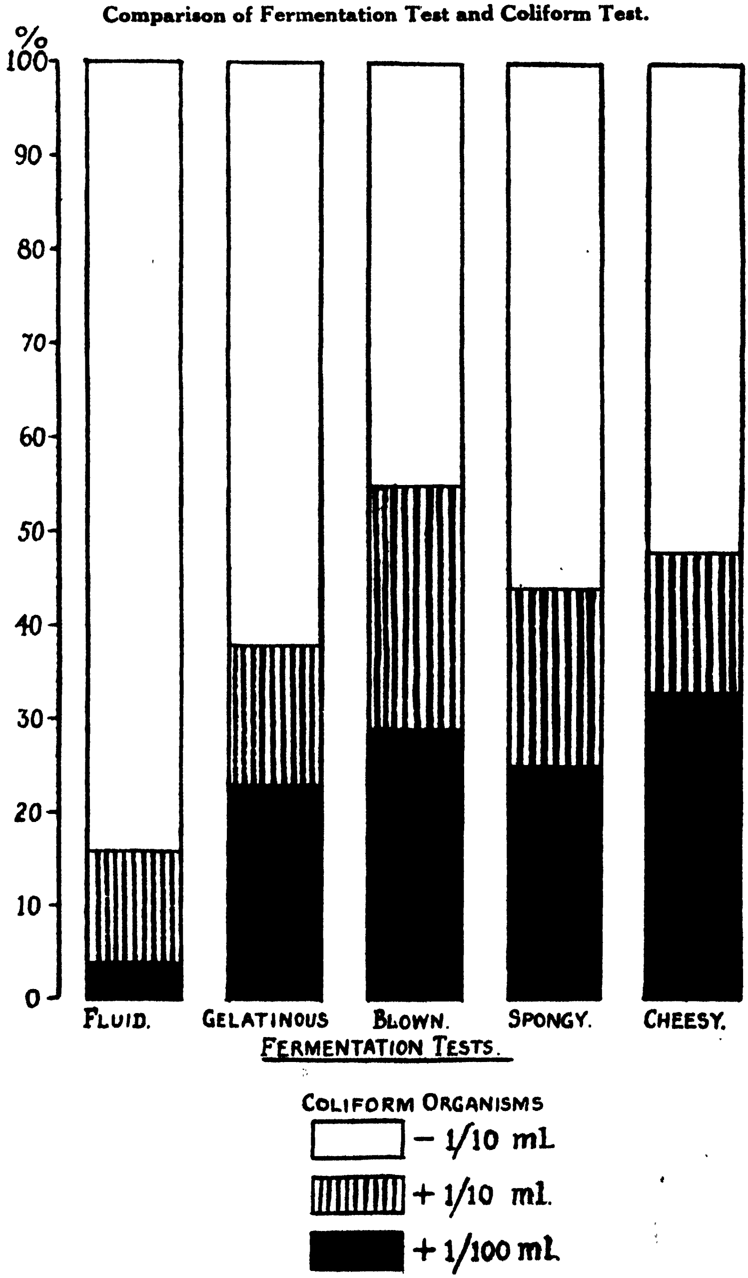


Table XX it will be seen that of 352 samples which contained large numbers of coliform organisms only 80 (23%) developed a blown curd and 38 (11%) a spongy curd. The results given in Table XXI and depicted in Chart II also demonstrate that there is no marked correlation between the coliform organisms content and the fermentation test results.

The results of numerous recent investigations on the ecology of the coliform bacteria of milk may possibly have a significant bearing on the above apparent anomaly. As many as 50 per cent. of the coliform organisms found in a raw milk supply may be of the Bacterium aerogenes type, originally derived from soil, herbage and cattle food. These are not primarily intestinal organisms, and many strains have been isolated from dairy products which grow better at 22°C. than at 37°C.

Such organisms may possibly produce acid and gas in a selective medium when incubated for 72 hours at 37°C., but may not be able to bring about a gassy fermentation in milk in 24 hours at 38°—40°C., when inhibited by the antagonistic action of a mixed bacterial flora.

The fermentation test carried out under these conditions may be of some value to the cheesemaker (though it is doubtful whether the results obtained with 40 ml. in a test-tube will be comparable to those obtained in the cheese vat), but it will not serve as a reliable indication of contamination with excessive numbers of coliform organisms.

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THE VALUE OF SECOND-GROWTH POTATO TUBERS FOR SEED PURPOSES.

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Introduction.

Secondary growth in the variety Kerr's Pink was prevalent in 1933 as a result of the prolonged dry weather, and this afforded an opportunity to study the value, for seed purposes, of these secondarily produced tubers as compared with normal seed. The consensus of opinion is against using them for seed, apparently because they are considered to be immature and, in consequence, liable to rot in storage. On the other hand the view had been expressed that this very immaturity would result in a more vigorous crop. The writer has, however, already shown (1) that immaturity *qua* immaturity confers no advantage on the tubers for seed purposes, but that the vigour of the crop obtained from immature tubers is due entirely to them escaping infection with virus diseases. The problem then was to investigate whether these secondary tubers did produce a markedly more vigorous and less diseased crop than normal tubers of the same size. It is admitted that the question would have been better studied on tubers from plants known to be virus infected but unfortunately it has never happened that conditions inducing secondary growth have occurred when a sufficiently large bulk of diseased material was available. The crop chosen was Kerr's Pink originating from one of the successful seed potato centres and containing less than 0.5 per cent. of visible virus symptoms during the growing season of 1933. Since, however, it was grown during 1933 in the neighbourhood of the writer's virus museum in which small stands of diseased material of many varieties are maintained, it was probable than sufficient infection of the Kerr's Pink would occur to justify a trial, in 1934, of the incidence of disease in normal and secondarily produced tubers.

Lay-out of Trial in 1934.

The crop was lifted by hand on the 5th and 9th October, 1933, care being taken to avoid detaching secondary tubers from the 'primary' ones. The crop was then immediately boxed after grouping the tubers in the following four classes : (I) Large normal tubers of ware size which had not produced any second-growth tubers; (II) Large 'primary' tubers of similar size to (I) but which had given rise to secondary growth; (III) Small normal tubers with no secondary tubers and of a size comparable with

the following class; (IV) which were small secondary tubers detached from Class II tubers and averaging a little under two ounces in weight.

Eight replications, each of fifty-four tubers, of these four classes of seed tubers were laid down on 17th April, 1934, and observations were made on the plots during the growing season. Little or no difference in vigour could be detected between the crops grown from the two large-tuber classes, both of which were definitely better than the small-tuber classes. Of these latter the secondary tubers (Class IV) appeared to be the less vigorous in all stages of growh.

Comparison of Disease Incidence and Yields.

Table I summarises the observations made on the occurrence of the only two virus diseases visible on the plots, and it will be seen that an appreciable amount of transmission had occurred in the parent crop during 1933. As perhaps ought to have been expected from the conditions of infection and of selection of the tuber-classes, the experimental errors were somewhat high and there was no indication that the differences in infection found in the first three classes had any particular significance. The incidence in the small secondary tuber class, however, is definitely less than that in the large primary tuber class and approaches significance, without actually attaining it, when compared with Classes I and III.

TABLE I.

Incidence of Virus Diseases, per plot, in Four Classes of Seed Tubers.

Class.	*Mean Mosaic.*		*Mean Leafroll.*		*Mean Total Virus.*	
	No.	%	*No.*	%	*No.*	%
Large Normal	4.6	8.56	1.5	2.78	6.1	11.34
Large Primary	6.5	12.04	0.7	1.39	7.2	13.43
Small Normal	4.7	8.80	1.5	2.78	6.2	11.58
Small Secondary	3.6	6.71	0.5	0.93	4.1	7.64

The crop from each unit plot was lifted separately, graded into ware, seed, and chats, and the data which is given in Table II were examined statistically. These results may be summarised as follows: (*a*) The large tuber-classes, irrespective of whether they had produced secondary growth, gave a significantly larger total yield than the small tuber-classes, and a significantly smaller proportion of ware; (*b*) The differences in total yield and in proportion of ware to total crop in the two classes of large tubers were not significant; (*c*) There was no

difference in total crop obtained from the two classes of small tubers, but the small secondarily-produced tubers gave a significantly higher proportion of ware in the crop.

TABLE II.

Yields (lb.) from Four Classes of Seed Tubers.

Class.	*Mean Yield in lb. per Plot (54 Tubers).*				% *Ware*	% *Seed*	% *Chats*
	Ware.	*Seed*	*Chats*	*Total Crop*			
Large Normal	84.25	24.62	5.62	114.50	73.58	21.51	4.91
Large Primary	77.37	26.62	6.00	110.00	70.34	24.20	5.45
Small Normal	80.50	16.00	5.12	101.62	79.21	15.74	5.04
Small Secondary	81.50	11.62	2.75	95.87	85.01	12.18	2.87

A comparison of the two Tables clearly shows that the proportion of ware to total crop varied with the freedom from virus symptoms, and supports the belief that the relatively healthy condition of the crops from the small secondary tubers as compared with all the other classes of seed-tubers is to be regarded as significant. At the same time this freedom from virus was not sufficiently advantageous to the small tubers to enable them to produce the same total weight of crop as the large-tuber classes.

Summary and Conclusions.

(1) The trial consisted of eight replications of four classes of seed-tubers: (*a*) Large Normal; (*b*) Large Primary (*c*) Small Normal; (*d*) Small Secondary.

(2) Large primary tubers showed rather more virus infection, with a smaller total crop and lower proportion of ware, as compared with similar tubers which did not produce secondary growth. None of these differences, however, was mathematically significant.

(3) The small normal tubers showed as much disease as the two large-tuber classes. They gave a significantly smaller total yield with a higher proportion of ware than the large-tuber classes, whether these latter had produced secondary growth or not.

(4) The small secondary tubers had definitely less disease than the other classes and gave a significantly higher proportion of ware. The total yield was not significantly different from that of the small normal tuber-class.

(5) Although the above facts show that the resumption of growth by a tuber in the autumn does not affect its value when planted as seed, the prejudice against such tubers is probably justified since the detaching of the small secondary growths exposes wounds which induce rots in storage.

(6) The healthier condition of the small secondary growths is interesting and is worth following up, but the higher proportion of ware obtained when such tubers are planted as seed does not compensate for the low total yield.

Acknowledgment.

Acknowledgement is due to the Laboratory Assistant, Mr. G. L. Turner, for the assistance he gave in carrying out these field trials.

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THE EFFECTS OF VARYING THE DISTANCE TO WHICH SWEDES ARE SINGLED.

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Introduction.

Reliable information on which advice to farmers could be based, as to the probable behaviour of swede crops, has proved very difficult to obtain. Some of the reasons for this have been pointed out in a previous paper (1) and amongst the most serious is the incidence of disease. Finger and toe can be guarded against quite effectively by sowing a resistant variety such as Wilhelmsburger, together with a reasonable use of lime, but other diseases are much more recalcitrant and their occurrence often stultifies any advice which may be offered. The conclusions reached in New Zealand by Levy (2) and Neill (3) that one disease at all events (dry-rot) could be minimised by close spacing of the roots suggested that other diseases spread by splashing rain might similarly be reduced, so that it was decided to test this possibility by means of field trials. Such

trials, involving varying the singling distance, also seemed desirable since in the work at Bangor referred to above (1) it was found that a significant increase in yield was obtained by a closer spacing than that normally adopted.

Lay-out of Trials.

With the above objects in view trials with the variety Wilhelmsburger were laid down both in 1933 and 1934. They consisted of twenty-four plots each of one-fortieth acre, or four rows of forty yards in length. This allowed of eight replications for each of the three distances to which the roots were singled, *viz.*, 8 inches, 11 inches and 14 inches. The unit plots were randomised so as to distribute as fairly as possible any effects due to soil variation or to interference between adjoining plots singled to different distances. As a further precaution against error due to this latter cause, all observations were made on the two inner rows of each unit plot. The personal error in estimating distances was eliminated by the use of measuring sticks when singling, a method which, though slow, was found by subsequent measurement to give a close approximation to the uniform intervals between plants required by the problem.

Incidence of Diseases.

Mildew (*Erysiphe polygoni*) was extremely severe in 1933 and rather less so, though still bad, in 1934. Apart from this no disease was really serious in 1933, whilst in the following year the crops were unusually healthy, and no useful data on disease incidence could be collected. The reason both for the prevalence of mildew and the comparative freedom from other diseases can be found in the extremely dry summers experienced. The following Table I shows that in 1933 the rainfall only reached the average for the last twelve years in January and March, whilst except for heavy rain in May and December the year 1934 was also singularly dry.

Careful observations were made during both years as to the prevalence of the following diseases : mildew, finger and toe, bacterial crown rot, bacterial root rot, dry-rot and Cercospora leaf-spot. It may be said at once that mildew was uniformly distributed over the foliage and no difference in intensity could be detected in the different plots. Finger and toe was quite negligible in both years, even on adjacent susceptible varieties. The incidence of the remaining diseases in 1933 is discussed below.

TABLE I.

Rainfall in Inches at the College Farm, Bangor.

Month.	*Average during 12 years 1923-1934.*	*1933.*	*1934.*
January	5.00	5.91	3.79
February	3.05	2.67	0.48
March	2.68	2.28	2.79
April	2.90	0.67	2.25
May	3.29	1.97	5.20
June	2.72	1.90	1.66
July	2.94	1.66	1.04
August	4.49	1.65	3.80
September	4.20	1.46	3.89
October	5.40	4.85	5.57
November	5.41	1.48	2.40
December	4.79	1.17	7.08
Total	46.92	27.67	39.82

Bacterial diseases (Crown Rot and Root Rot).

Comparisons of the casual organisms of these two diseases in the laboratory point to them being strains of *Bs. caratovorous*, differing from each other and from the organism named only in small cultural details which need not be specified here. The root-rot disease spreads upward from the underground parts and is introduced into the plant mainly through bruises produced during cultivation of the crop. In swedes the rot involves the rind as well as the softer inner tissues, whereas in turnips the rind often remains intact so that the root appears sound until an attempt is made to lift it. The crown rot on the other hand attacks the terminal bud region and extends down the " neck " into the bulb, most of the inner tissue of which may, in a bad case, be changed into a grey pulp. This latter disease affects both swedes and turnips, the swede crop being the more generally but less severely attacked. The following Table II shows that bacterial root rot was not serious in 1933 and that the closest spaced roots escaped entirely.

TABLE II.

Percentage Infection with Bacterial Root Rot.

Spacing.	% *infected but not destroyed.*	% *destroyed.*	% *Total Infection.*
8 ins.	0.00	0.00	0.00
11 ins.	0.20	0.11	0.31
14 ins.	0.00	0.52	0.52

Bacterial crown rot also was less serious in 1933 than in some previous years, though the incidence was higher than in the case of the root rot. From Table III it is clear that both in number of plants attacked and the subsequent progress of the disease from the neck into the bulb there is a steady increase with the increase of space between roots.

TABLE III.

Incidence of Bacterial Crown Rot.

Spacing.	*Per cent. Roots attacked.*	*Severity of Attack expressed as per cent. of Diseased Root.*		
		(1) *Slight.*	(2) *Moderate.*	(3) *Severe.*
8 ins.	9.08 ± 0.38	78.08 ± 2.54	15.09 ± 1.02	6.83 ± 0.31
11 ins.	10.44 ± 0.38	65.18 ± 2.86*	27.20 ± 1.82*	7.20 ± 0.43
14 ins.	11.23 ± 0.46	69.61 ± 1.91*	29.67 ± 1.81*	9.72 ± 0.39*

*—Significant difference from 8 inch spacing result.

A slight attack is defined as one in which no progress has been made down the neck and the wound has dried out. A moderate attack still shows a wet pulp but little more than the neck of the swede is involved, whilst severe attacks are those in which the rot is still progressing well into the bulb.

The explanation of the difference in attack between the different plots is to be sought in the conditions facilitating entrance of the organism. Any factor causing a wound or the death of the terminal bud will supply the necessary conditions in which a soil organism, splashed into the crown, can set up a rot. It was at first thought that flea beetle attack might result in such conditions, but a careful count showed no significant difference in the incidence of attack by the beetle in the different plots; the eight inch plots having 20.63 per cent. of the plants attacked, the eleven inch plots 23.69 per cent., and the fourteen inch plots 19.59 per cent. Another possibility was damage by swede midge, but the writer's colleague, Dr. W. M. Davies, has already shown (4) that no association can be found between swede midge attack and the occurrence of crown rot. The variety Wilhelmsburger used in the trials is definitely more susceptible than many varieties to crown rot, although the disease usually fails to make much progress owing, perhaps, to the presence of a particularly close network of vascular tissue at the base of the neck. It is believed that one reason for the rather high susceptibility of this variety to attack is the spreading habit of the

foliage, which exposes the crowd bud more than is the case in erect varieties. The flaccid condition of swede leaves severely affected with mildew will add also to the likelihood of crown rot supervening, although a direct connection is very difficult to prove.

Leaf-spot (Cercospora sp.).

Table IV indicates that this disease occurred to a greater extent on the eight-inch plots than on the others, although the degree of attack was slight everywhere.

TABLE IV.

Percentage Infection with Cercospora Leaf-Spot.

Spacing.	*Degree of Infection.*			
	Slight.	*Moderate.*	*Severe.*	*Total.*
8 ins.	0.60	0.08	0.14	0.82 ± 0.093
11 ins.	0.10	0.00	0.20	*0.30 ± 0.042
14 ins.	0.12	0.00	0.12	*0.24 ± 0.031

*—Significant difference from 8 inch spacing result.

Dry-rot (Phoma lingam).

It has already been mentioned that in New Zealand it is claimed the disease is less serious when roots are closely spaced. This is not surprising since it is spread by splashing rain, and the closer the canopy of foliage the less exposed is the bulb. In the present trials only 0.25 per cent. of the plants were attacked by dry-rot, and these were found only in the fourteen-inch plots.

Effect of Different Spacing on Number and Weight of Roots.

Theoretically, the result of varying the singling distance was to give 175 plants in the eight-inch plots, and 128 in the eleven-inch plots for every 100 plants in the fourteen-inch plots. In practice, however, some losses occurred, and more so in the closest spaced roots than in either of the others. The increased mortality of these eight-inch spaced plants was not due to loss by disease but rather to the difficulty of selecting vigorous seedlings at such short intervals and the increased risk of dislodging seedlings in subsequent cleaning operations, a risk which was greater in 1934 than in 1933 owing to the stony character of the soil. That this loss was a serious matter is shown by the last two columns of Table V, but even so there was a significant

excess of numbers of roots in the eight-inch plots over those in the eleven-inch and fourteen-inch plots in both years.

TABLE V.

Effect of Different Spacing on Numbers of Plants Surviving.

Spacing (inches).			*Number Plants per Acre.*				
Initial.	*Final.*		*Estimated.*	*Actual.*		***Number Plants Lost.***	
	1933	*1934*		*1933*	*1934*	***1933***	*1934*
8	8.9	10.5	28080	26240	21216	1840	6864
11	11.4	12.3	20280	19656	18096	624	2184
14	14.4	14.2	16224	15600	15912	624	312

The effect of the increase in number of roots was to produce in 1933 an extra one and a half tons in the eight-inch plots over the yield from the 14-inch plots, a difference which is mathematically significant. In 1934 the same tendency was apparent, although the differences here just fell short of being significant. Reference to columns two and three of Table VI will show, however, that the size of the individual root was reduced parallel with a reduction in the spacing but, although the reduction in size was a significant one, it was not sufficient to bring the total yield of the widely spaced roots up to that from the eight inch plots.

TABLE VI.

Effect on Yield of Varying the Singling Distance.

Spacing.	*Mean Weight per Root (lb.)*		*Mean Yield per Acre.*							
	1933.	*1934.*	*1933.*				*1934.*			
			T.	*C.*	*Q.*	*Lb.*	*T.*	*C.*	*Q.*	*Lb.*
8 ins.	1.942	2.44	22	15	0	0	24	0	0	0
11 ins.	2.384	2.80	21	10	0	0	23	7	0	2
14 ins.	2.935	3.13	21	2	2	0	23	0	3	21

Farmers have a natural preference for large roots, but in point of fact excessively large roots contain an undue proportion of water, and the ideal to be aimed at should be a crop of medium sized roots containing the highest possible dry matter per acre. An analysis carried out in this laboratory by Mr. G. Ll. Evans, B.Sc., in which the unit sample consisted of cores from fifty different roots, gave the result shown in Table VII. Not only does the percentage dry matter fall off as the size of the root

increases, *i.e.*, with increase in the singling distance between roots, but this loss is mainly in the sugar content. It follows from the reduced yield that, as Table VII shows, wide spacing will considerably reduce the dry matter per acre, and with it, the total feeding value of the crop.

TABLE VII.

Dry Matter Content of Roots Singled to Different Distances.

Spacing.	*Per cent. Dry Matter.*	*Dry Matter per Acre.*			
		T.	*C.*	*Q.*	*Lb.*
8 ins.	9.68	2	6	2	6
11 ins.	9.69	2	5	1	0
14 ins.	9.26	2	2	2	20

It should be remembered that the composition was determined in 1934 when, owing to the higher mortality of the plants initially spaced at eight inches apart the final spacing was found to be 10.5 inches. It cannot be doubted that the increase shown in dry matter per acre would be considerably greater in the previous year when the space between roots remained much as at singling time.

Summary and Conclusions.

(1) The trials have shown (*a*) that closer spacing tends to reduce the incidence of bulb diseases such as dry-rot, bacterial crown rot, and perhaps bacterial root rot. It has no influence on the incidence of mildew and almost certainly none on the occurrence of finger and toe; whilst it tends to facilitate the spread of Cercospora leaf-spot, a less serious disease than any of the foregoing. (*b*) Close spacing will increase the fresh weight yield by at least a ton per acre and at the same time increase the feeding value of the individual roots. Since a medium sized root has a higher feeding value than a large root, the acre can usefully accommodate the extra 8,000 roots provided by closer spacing. At the same time these extra roots serve as an insurance against loss by disease, for a " thin " crop could only result from a very heavy attack.

(2) The only disadvantage incurred by closer spacing would seem to be the extra cost of singling, but no reliable estimate of this was possible in the trials owing to the artificial conditions introduced by the use of measuring sticks. In any case it is only one amongst many factors which affect the cost of production of the swede crop, and it is believed therefore that the trials

show a considerable balance in favour of singling the root crop closer than is at present customary.

Acknowledgments.

The writer is glad to acknowledge the help given by Mr. Haydn M. Williams, M.Sc., in the 1933 trials and that of the Laboratory Assistant, Mr. G. L. Turner, throughout this work.

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A NOTE ON "BROWN HEART," A NEW DISEASE OF SWEDE, AND ITS CONTROL.

By T. Whitehead, Ph.D., M.Sc., A.R.C.Sc.,
University College, Bangor.

The attention of agriculturists is drawn to a malady of swedes which was first recognised in North Wales in November, 1932, this being the first record in the British Isles so far as the writer is aware, since 1913, when it was observed in Western Ireland by Pethybridge. During the last two years it has been recorded from Scotland and from several counties in England. It has assumed serious proportions in Canada and in the South Island of New Zealand. Externally there is no sign of disease, but internally the flesh at some distance from the rind is stained brown in more or less concentric zones. These slices of the diseased tissue are translucent, and the whole appearance is reminiscent of " water-core " in apples. No organism has been found associated with the symptoms, and there is no reason to doubt that the disease is due to some form of mal-nutrition. Although there is a fairly wide range of susceptibility in different varieties, none is immune. It has occurred on different types of soil and in crops grown with and without the aid of artificials. Unless secondary organisms invade the affected tissues there is

no rotting, nor is the food value appreciably diminished. There is no evidence as to whether palatability to stock is affected, but it entirely prevents any possibility of sale for human consumption.

At the instance of Dr. Pethybridge of the Ministry's Plant Pathological Laboratory, the writer laid down trials in 1934 on five farms, of which four were in Caernarvonshire and one in Anglesey, with the object of testing the Canadian claim to control the disease by the application of borax at sowing time. The disease did not develop on one Caernarvonshire farm, but the following Table shows that in each of the other four centres a considerable degree of control was effected by applying borax at the rate of ten pounds per acre, and that no improvement was obtained by doubling the rate of application.

TABLE.

Control of "Brown Heart" of Swedes by the application of Borax.

Centre.	*Per cent. Badly Diseased.*			*Total per cent. Diseased.*		
	Un-treated.	*10 lb. Borax.*	*20 lb. Borax.*	*Un-treated.*	*10 lb. Borax.*	*20 lb. Borax.*
Bodorgan	17.3	2.0	2.0	37	9	8
Half-way Bridge	16.0	0.0	0.0	36	0	0
Pentir	26.6	1.3	4.0	55	13	13
College Farm	6.6	1.8	0.0	29	8	3

ABSTRACTS, REVIEWS, AND BIBLIOGRAPHICAL NOTES.

ANIMAL NUTRITION.

Abstractor:

R. O. DAVIES, M.Sc., University College, Aberystwyth.

Calcium-deficient Roughages; Effect of upon Milk Yield and Bone Strength in Cattle.

R. B. BECKER, W. M. NEAL, and A. L. SHEALY. *J. Dairy Soc.* (1934), 17, 1-10.

Over a period of years it was found that the addition of bone meal as 2 per cent. of the concentrates to a ration high in protein, energy constituents and phosphorus, but low in calcium, resulted in the case of twelve Jersey cows to an increased milk yield and a more persistent production throughout longer lactation periods. At the same time the cows attained a high stage of mineral storage as evidenced by the increased strength of their bones. R.O.D.

Calves; The Effect of two different Calcium Phosphorus Ratios upon the Growth of.

P. J. DU TOIT, A. I. MALAN, and J. W. GROENEWALD. *Onderstepoort J.* (1933), 1, 421-4.

There is no evidence that altering the calcium-phosphorus ratio produced better growth in calves under the conditions of the experiment *i.e.*, probably of calcium and phosphorus sufficiency. As this experiment throws considerable doubt on the practical significance of varying calcium phosphorus ratios in the nutrition of calves, it is being followed up with further work along the same lines. R.O.D.

Cattle; Minimum Mineral Requirements of.

P. J. DU TOIT, A. I. MALAN, and J. W. GROENEWALD. *Onderstepoort J.* (1934), 2, 565-605.

Data are presented on the mineral requirements of growing and lactating cattle. Radiographs of selected bones of phosphorus and calcium deficient animals are given. A lactating animal's defence against mineral deficiency is decrease in milk production, the greatest decrease being noticeable when the deficiency is greatest. R.O.D.

Cattle Experiments 1883-1933. 1. Extracts from Reports of Research Laboratory. 2. Preliminary reports on some unpublished experiments and investigations.

V. STEENSBERG and P. S. ØSTERGAARD. *156th Rep. Roy. Vet. and Agri. Coll., Copenhagen* (1934).

A summary is given of published work describing experiments on calf rearing, fattening and milk production. Heather (the tops cut by a mower) was willingly eaten by cows, replaced straw in the ration (4-5 kg. per day) and slightly increased milk yield without reduction of fat content. Dried brewers' grains were found to be of about the same nutritive value as bran. The vitamin A content of winter butter was maintained at the summer level by feeding carrots, well cured hay and A.I.V. Silage. R.O.D.

Dairy Cattle; The Mineral and Vitamin Requirement of.

J. A. CRICHTON. *Scottish J. Agri.* (1934), 17, 197-201.

A short review is given of the practical significance of recent experimental work on minerals and vitamins, with special reference to the dairy cow. R.O.D.

Dairy Cows; Calcium and Phosphorus Metabolism in. 7. The Effects on Calcium and Phosphorus Metabolism of feeding Rations low in Calcium for long periods.

E. B. MEIGS, W. A. TURNER, E. A. and L. A. SHIRM. *J. Biol. Chem.* (1934), 105. Proc. Ix-Ixi. (Bur. Dairy Indust., U.S. Dept. Agric.)

After several months on rations low in calcium, cows may utilise about 50 per cent. of the intake. Over a long period the total loss of calcium from the body probably does not exceed 20 per cent. of that originally present. Nutritive disasters on rations low in calcium are attributed to the low vitamin A content of such rations rather than to their low calcium content. R.O.D.

Legume Husks; The Nutritive Value of.

R. G. LINTON and A. N. WILSON. *J. Agr. Sci.* (1934), 24, 260-7.

Pea husks have a fairly high starch equivalent notwithstanding their high fibre content. Although containing only a negligible quantity of protein, their inclusion in a diet, particularly at lambing time, may have a definite beneficial effect, especially when mineral mixtures are not supplied. R.O.D.

Marrowstem Kale; Feeding value of.

W. WÖHLBIER and W. SCHRAMM. *Biedermanns Zentralbl. B. Tierernährung* (1934), 6, 1-18.

The results of digestibility trials with sheep on three varieties of marrowstem kale are given. The digestible protein in the leaves was three to four times as high as in the stems. The starch value was also higher owing to the greater fibre content of the stems. Hence the proportion of leaf to stem is the main factor in evaluation as fodder.

R.O.D.

Milk Production; The Quality of Protein in relation to.

A. B. FOWLER, S. MORRIS, and N. C. WRIGHT. *Scottish J. Agr.* (1934), 17, 261-9.

For accurate rationing it is essential to take account of the quality as well as the quantity of the protein fed. It is noted that the biological values are directly related to the lysine contents of the various rations, and it appears that the latter may offer a practical basis for calculating requirements for milk production. In this connection it is of interest that foodstuffs which can be readily produced in Great Britain *i.e.*, blood meal, meat meal, beans and peas have the highest lysine contents and therefore constitute the best sources of protein for milk production.

R.O.D.

Molasses. Incorporated in Grain Mixtures.

G. BOHSTED, B. H. ROCHE, J. M. FARGO, I. W. RUPEL, J. G. FULLER, and P. E. NEWMAN. *Proc. Amer. Soc. Animal Production* (1933), 52.

Ten per cent. molasses in grain mixtures for dairy cows, fattening

steers and lambs, and growing and fattening pigs did not result in significant differences in gains or market-production. In all cases except self-fed lambs slightly more feed was required to produce 100 lb. gain on the molasses ration. R.O.D.

Oats; The increase of the Protein content of, obtained by delaying the application of Nitrogen.

A. M. SMITH. *Scottish J. Agri.* (1934), 17, 404-10.

Evidence is brought to show that in general, a significant increase in the percentage nitrogen of the grain is effected by delaying the application of nitrogenous manure. This increase is considered to be of considerable economic importance as a conservative estimate shows it to be equivalent to about 9s. 6d. per ton of oats. R.O.D.

Palatability; The Relative of Seeds Mixtures, and a Study of the Influence of Fertilizers on Natural Hill Pastures.

W. E. J. MILTO.. *Empire J. Expt. Agri.* (1934), 2, 51-64.

Free choice of grazing by sheep among plots differently sown with single species of simple seeds-mixtures shows that, although timothy was not the hardest grazed among the pure plots, it formed the basis of the most palatable mixtures. On the mixture plots the sheep selected mixtures as such rather than individual species from mixtures. Red clover, when grown in plots which allow the animal an alternative diet, has a very high palatability. Complete manuring yielded the most palatable herbage and the effect of lime was greater than that of superphosphate. R.O.D.

Pasture; Nutritive Value of. X. The Utilisation of Young Grass by Swine.

H. E. WOODMAN and D. B. NORMAN. *J. Agr. Sci.* (1934), 24, 93-108.

Data are included to illustrate the all round superiority of young grass as a source of digestible nutrients for sheep (and other ruminants) as compared with pigs. If satisfactory rates of live weight increase are to be realised in the case of growing pigs on grass, attention must be directed to ensuring that the animals are consuming, besides the grass, an adequate ration of concentrated meal. When grass constitutes a substantial portion of the dietary of pigs, it is not feasible to anticipate such rapid increase in live-weight as is possible when the ration is composed wholly of the usual mixture of concentrated meal.

R.O.D.

Pasture; Nutritive Value of. XI. The Composition and Nutritive Value of Winter Pasturage.

H. E. WOODMAN and P. M. OOSTHUIZEN. *J. Agr. Sci.* (1934), 24, 574-597.

A leafy winter growth may closely resemble a spring growth in respect of mixture of grass species, height and stage of growth and yet be very definitely inferior in composition, digestibility and feeding value. The inferior composition and nutritive value of the winter pasturage are held to be a consequence of a cessation of growth in the grasses as a result of cold and frost, this cessation being accompanied by physiological processes leading to a reorganisation of the material already

in the plants as a means of defence against the inclement conditions. The depressing influence of winter conditions on the composition and digestibility of pasture herbage is less pronounced with short, leafy herbage than with longer and more advanced grass. The loss of palatibilty resulting from frost action is less in the case of short, leafy grass than with grass in a more advanced stage of growth.

R.O.D.

Pasture Studies IV. Nutritive Value of Pasture Herbage: Quality of Protein.

E. W. Crampton. *Empire J. Expt. Agr.* (1934), 2, 337-48.

Herbage obtained from natural and fertilized pastures was fed to newly weaned rabbits. In addition to the lots receiving only grass, other lots received in addition to the basal diet of grass a supplement consisting of one or more of the essential amino acids. The addition of a mixture of the essential amino acids not only increased growth, but made equally efficient the fertilized and unfertilized herbage. That quality of protein may be a factor in the nutritive value of pasture grass would thus appear to be established. It is hoped that further work will yield more definite information as to what amino acids may be deficient in the unfertilized grass, and whether fertilization of pasture may actually alter the quality of protein in the herbage. R.O.D.

Phosphorus Deficiency; The Influence of—in Dairy Cows on the Coefficient of Digestibility and the Balance of Calcium and Phosphorus.

W. H. Riddell, J. S. Hughes, and J. B. Fitch. *J. Agr. Res.* (1934), 48, 167-70.

Lactating dairy cows in advanced stages of aphosphorosis were found to digest their feed as efficiently as the normal control. The lowered feed utilization by the phosphorus deficient cattle did not result from inefficient digestion of the feed. Cows in this condition were found to be in negative balance for both calcium and phosphorus. R.O.D.

Pig-Feeding; A Complex—Experiment.

F. Yates. *J. Agr. Sci.* (1934), 24, 511-531.

The results of a pig feeding experiment conducted at Rothamsted are discussed. The experiment showed that green food was essential to young pigs under the conditions of the experiment, that pigs fed on a wet mash grew at a faster rate than pigs fed on dry meal, the difference being due to the greater quantity of food consumed by the former, and that the effects of numbers in a pen (giving equal floor space per pig) was negligible in spite of the greater possibilities of exercise in the larger pens. R.O.D.

Protein: Proportion of—needed in the Grain Mixture fed with Pasture.

Ohio Agri. Expt. Stat. Bimonthly Bull. (1934), 19, 44-8.

Two groups of cows in the summer of 1933 were fed different levels of protein on pasture. It is concluded that under ordinary pasture conditions a little more milk is obained with the high protein ration but at an increased cost per gallon. R.O.D.

Sheep Feeding Experiments.

W. G. R. PATERSON. *Trans. Highl. and Agr. S. Scotland* (1934), 46, 146-68.

A brief review is given of trials on the winter feeding of sheep for the production of mutton. A somewhat restricted allowance of swedes with a fairly liberal ration of concentrates was found to be distinctly superior to a more liberal allowancve of swedes and a relatively smaller ration of concentrates. Silage appeared on the whole less suitable for fattening hoggets than swedes or beet pulp. The per cent. of carcass weight to live weight is likely to be quite as high from sugar beet pulp as from swedes, but silage is in that respect rather inferior to either of these foods. R.O.D.

Silage; Effect of—made with addition of acid on Digestibility, Nitrogen, Calcium and Phosphorus Balances in Cattle, Sheep and Pigs.

F. GRAMATZKI. *Ztschr. f. Tierizuchtung u. Züchtungsbiol* (1933), 28, 433-50.

Metabolism experiments were made with different animals fed on silage, with and without the addition of mineral acids (hydrochloric and phosphoric). Utilisation of nitrogen was reduced by addition of acids, and the phosphorus and calcium balance reduced. These results refer to the feeding of silage alone. Such silage, mixed with other foodstuffs, would probably give better results. R.O.D.

Wool Growth in Sheep as affected by the Carbohydrate Content of the Diet.

A. H. H. FRASER and J. E. NICHOLS. *Empire J. Expt. Agr.* (1934), 2, 9-19.

The addition of maize starch to the maintenance ration of young Cheviot sheep produced a significant increase in both fleece weight and body weight. The increase of fleece weight was largely due to a definite increase in fibre thickness, a slight increase in the fibre length, and possibly also to an increase in the proportion of follicles actively elaborating fibres. Additional carbohydrate in the diet, therefore, led to the increased production of a substance predominantly protein in nature. R.O.D.

LIVE STOCK.

Abstractor:

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Albino Cattle.

L. J. COLE, E. E. VAN LONE and I. JOHANSSON. (1934), *J. Hered.*, Vol. 25, pp. 145-56.

For some twenty years past there have been reports in scientific Journals concerning albino cattle. In this paper we have a review of such cases and the addition of another one which occurred at a farm in Wisconsin and shows some relationship with the previous cases reported in Minnesota.

These albino cattle were, at birth, practically devoid of pigment, but gradually as the animals approached maturity they developed some pigment in the iris of the eye and in the hair. Bulls appeared to attain

a higher degree of pigmentation than cows. In mature animals, and especially in bulls, a peculiar kind of "ghost pattern" was developed. White spotting was apparently inherited independently of the gene for partial albinism. Only one animal was produced from matings of albino x albino. Mated to black and white, and red and white cattle, all the calves produced were black and white showing that, underneath this albinism, these cattle carried the gene for black. The data may be considered to support the hypothesis that the gene for this extreme reduction of pigment in cattle is a recessive allelomorph to the gene for normal pigmentation. The albino cattle showed pronounced dislike of strong sunlight. One of the bulls was a very poor breeder. As regards milk production, the albino cow was equal to normally pigmented Holstein cows of the experimental herd and there were no other signs of decreased vitality. A.D.B.S.

Advanced Registry Policy for Pure-bred Swine.

G. B. Rothwell and A. W. Peterson. (1934), *Dominion Dept. of Agric., Ottawa, Canada.*

The Canadians have established a system of pig recording which appears to be working very well indeed. Inaugurated in 1928, it may now be considered to be well established. The policy is, "to provide the swine industry with a system of pig testing organized on a national basis." Individual sows, by means of their progeny, are tested for prolificacy, feeding ability and carcase quality. To a breeder, the value of this policy lies in the fact that as a result of the test he obtains a knowledge of the performance of his sows. Since the records are published in detail, particularly as regards the results of the carcase tests, it is possible for the breeder not merely to eliminate the pigs with low scoring carcases from his herd, but to discover the existence of those other herds which can supply any deficiency which he finds in his own. This should be of the greatest value in a constructive breeding policy.

Breeders are required to keep private herd records. Inspections of the herd are made by Officers of the Dominion Department of Agriculture when the pigs are from four to eight weeks of age. All sows entered, and also their progeny, are then identified by tattooing the ears: the pigs are weighed, and at the same time nominations are made for the slaughter test. After being reared and finished for market, four of the five pigs nominated by the breeder are shipped to a designated packing plant (Central Slaughter House). The information derived from the carcase test is as follows:—

(1) Age in days from birth to slaughter;
(2) Cold carcase weight;
(3) Length of side;
(4) Depth behind shoulder;
(5) Depth of flank;
(6) Thickness of back fat at shoulder, loin and thinnest point;
(7) Weight of shoulders;
(8) Weight of middle bones;
(9) Weight of hams;
(10) Quality and thickness of belly;
(11) Firmness of fat;
(12) Grade of carcase.

To qualify, a sow must reach a certain standard in respect of each of the three main factors measured, viz.:—

(1) Production capacity of the sows; *i.e.*, fertility and ability to raise a litter;

(2) The capacity of the progeny of the sows for early maturity;

(3) The quality of the progeny as revealed by the slaughter tests.

Boars can qualify by siring at least three litters, the dams of which have qualified as a result of scores secured through such litters. No sow is permitted to complete a slaughter test with pigs from a litter of less than eight, nor with pigs which show a tendency to ridglings, rupture, hermaphroditism, black hair in white breeds, or such like marked disqualifying characters.

As already mentioned, there is published annually an Advanced Registry for pure-bred swine. For the year ending March 31st, 1933, this Registry contained the names of some 100 sows in addition to some boars.

With regard to the scoring chart, it is interesting to note that in scoring the carcase the Canadians consider that it is necessary to include the length of carcase and to divide up the points awarded for back fat into thickness and evenness. In addition to belly measurements, there are a series of measurements in respect of "balance of the side." Included herewith is the ham, the middle, and the shoulder. The ham must weigh not less than 25 per cent. of the carcase weight, while the shoulder must not exceed 25 per cent. of the carcase weight.

In this country, under the Pigs Marketing Scheme, we are content to grade our pigs solely on the thinness of the back fat and the thickness of the belly. In Canada, in addition to these measurements, the general distribution of the back fat is considered of as great importance as the actual thickness; the length of the carcase is of as great importance as back fat; while balance of side, which includes ham, is of as great value as the belly measurement. The method of grading the ham by a simple weighing measurement is one which ought to commend itself to the Pigs Marketing Board of Great Britain. A.D.B.S.

Beef and Dual Purpose Cattle Investigations (1933).

Report of the Chief of the Bureau of Animal Industry, U.S. Dept. of Agric.

Record-of-performance studies with beef Shorthorn steers at the United States Animal Husbandry Experiment Farm at Beltsville, Maryland, indicated that there were wide variations among pure-bred strains of Shorthorns in the efficiency with which they utilize their food. The range in time required to reach a finished weight of 900 lbs. was from 370 to 508 days. The quantity of beef produced from 100 lbs. of total digestible nutriments varied from 14.3 to 22.1 lbs. with animals of similar type, fed alike on the same feeds.

The United States Department of Agriculture are carrying out a fairly large scale investigation into the economy of dual purpose cattle. There are maintained at Federal and State Stations seven foundation herds of Shorthorns, three of Red Polls, and one of Devons. At each of these Stations the same plan of work is followed out, but the feeds used are those which predominate in the locality. The plan is to begin with the most promising available cattle of the various breeds and, by measuring the performances of their progeny, develop strains of known ability

with respect to beef and milk production. The economy of food consumption, as noted in the previous paragraph, is also taken into consideration.

The first female of these matings which has completed a year's milk record gave, on two milkings a day, 861 gallons of milk and 342 lbs. of butterfat, *i.e.*, 4 per cent. The first eleven steers of these matings show wide variations in the efficiency with which beef is produced. As regards the time taken to reach a finished weight of 900 lbs., they range from 425 to 523 days. As regards the number of pounds of dressed carcase produced for each 100 lbs. of total digestible nutrients eaten, the variation was from 14.9 to 18.6. It is significant that one steer, highly efficient in the production of beef, was by the same sire as the heifer mentioned above which completed her first lactation so creditably.

Records have been kept of the milk, grain, and alfalfa hay consumed by ten dual-purpose steer calves having an average birth weight of 85 lbs. At 505 lbs. (weaning time) they had consumed 6.4 lbs. of milk per pound of gain in weight, also an average, per steer, of 325 lbs. of grain and 388 lbs. of hay. A.D.B.S.

Beef Production and Quality as influenced by crossing Brahman with Hereford and Shorthorn Cattle.

W. H. Black, A. T. Semple and J. L. Lush. (1934). *U.S. Dept. Agric. Tech. Bull.*, No. 417.

The humped cattle, native to India, were first introduced to North America in 1849. It was not till 1906 that such cattle received much notice when there was a large importation made and the name " Brahman " was given to these animals. Their principal function lay in the fact that they were able to withstand the ravages of the Texas tick. The present paper discusses the quality of beef produced by crossbred Brahman cattle as compared to pure bred Hereford and Shorthorn cattle and covers nearly the whole aspect of the problem. The experiments were commenced in 1924.

On account of gaining more and eating practically the same quantity of feed, the pure bred Shorthorns and Herefords made more economical feed lot gains than did the Brahman crossbreds but there was no difference between the two lots in respect of shrinkage while in shipment. The dressing percentages of the Brahman crossbreds were from 2 to 4 per cent. higher than those of the Herefords and Shorthorns. A noteworthy point is that the Brahman crossbreds had on the average smaller heads, larger hides and smaller digestive tracts. The smaller digestive tract offers an explanation for the inclination of Brahman cattle to eat more frequently and less at a time than Herefords and Shorthorns.

As regards quality of the meat, there was only a very slight difference in favour of the pure breds, that from the Brahman crossbreds being slightly less tender. A.D.B.S.

Calving Ages of Pedigree Cows.

M. Plum and J. L. Lush. (1934). *J. Dairy Sc.*, Vol. 17, pp. 625-38.

The age at which dairy heifers should be mated for first calving is the principal subject dealt with in this paper. The writers find that the average age at which 570 pedigreed heifers in the U.S.A. calved for the first time was 27.1 months, but that more than half of them calved

before they were twenty-five months of age. Some significant differences were found concerning the different breeds, but over 70 per cent. of the data concerned Holsteins. The difference was also due, in certain cases, to different types of management or herd environment.

The paper goes on to deal with the number of cows calving at various ages and shows that the peaks are twelve months apart, beginning at twenty-four months. The writers suggest that this distribution should be taken into account in studying the relation of other variables to age at calving.

They further state that one-fourth of all pure bred calves are out of dams less than thirty-six months of age, and that one-half are out of dams less than four years and four months old, while only one-fourth are from dams as much as six years and three months old. This confirms the figures obtained in this country, that the average replacement in dairy herds is about 25 per cent. of the cows per annum.

A.D.B.S.

Congenital Tremor in Young Chicks.

F. B. Hutt and G. P. Child. (1934). *J. Hered.*, Vol. 25, pp. 341-50.

Congenital tremor is evident in chickens usually when they are standing, and as a rule is imperceptible when they squat. On occasion if the young chicks are crowded together, it may not be possible to observe the trembling very easily. Few of them survive longer than a week, and in these cases the trembling becomes less noticeable. After eight weeks of age there is no sign of the tremor, but the authors found that all but two of such chicks were markedly stunted. The anatomical or physiological defect responsible for the character has not yet been discovered.

Although only one of the chickens was raised to maturity, the writers have been able, from an analysis of their matings, to deduce that there is a hereditary basis for the character, and that this is probably dependent on two pairs of genetic factors. They consider this a more likely interpretation than that the character is a simple recessive.

A.D.B.S.

Defective Skulls of Pigs.

E. H. Hughes and H. Hart. (1934). *J. Hered.*, Vol. 25, pp. 111-5.

A large proportion of young pigs born are deformed. That more attention is not drawn to this subject is probably due to the large size of the litter of the sow. One or two more or less does not as a rule make a great deal of difference. This report comes from California and deals with Poland China pigs. The abnormality appears to be due to the lack of fusion of certain bones in the skulls, particularly those associated with the parietal. The openings have varied in length from six to sixteen millimetres and in width laterally from four to six millimetres. The condition is usually accompanied by a protuberance located in the centre of the forehead. The projecting part does not seem to be covered by a true outer epidermis. The affected pigs in this herd were as large as their litter mates and as strong. Few of them have been brought up to 200 lbs. liveweight, the majority dying soon after birth. The condition has more recently been observed in the Poland China herd of the University of California. The condition is probably widespread in occurrence and there is evidence that it has

existed in other parts of the United States. That it is hereditary there can be no doubt, and while the evidence is not conclusive, it would appear as though the condition described was due to heterozygosity of a single pair of factors the homozygous condition leading to death in utero. A.D.B.S.

Egg Production—Selection by Ancestors' Yields.

M. A. JULL. (1934). *J. Hered.*, Vol. 25, pp. 61-4.

The writer is of opinion that the actual number of eggs laid by a hen and by her ancestors, as well as by the maternal ancestors of her sire, has relatively little significance in breeding for egg production. He demonstrates this by the results secured from various matings of sires and dams selected on the basis of the dam having laid a minimum of 200 eggs during the first laying year. These results came from matings of Rhode Island Red birds and the production of 701 daughters sired by fifteen different cocks and out of 121 hens. These daughters were produced during three years—1928, 1929 and 1930. The hatching season each year occurred from March 17th to the first week in May. Housing conditions were identical, the rations fed and methods of feeding were the same. Artificial light was used during the winter months.

The 121 dams were selected on the basis of having laid a minimum of 200 eggs each. Four tables give the statistical results. From these it is apparent that in this selected group there is no significant relationship between the egg production of the dams and that of their daughters. The daughters of dams whose egg production ranged from 211-220 eggs laid better than the daughters of any other class of dams. In other words a dam that laid 270 eggs would, on the average, produce daughters that would lay no better than a dam which laid 220 eggs.

As regards the sires, the main egg production of the sires' daughter does not appear in significant relation to the egg production of his dam nor of either of his grand-dams.

The authors conclude that when a minimum first year record of 200 eggs is used as the basis of selective breeding stock, the actual number of eggs laid by any bird does not indicate the breeding ability of that bird, nor does the egg production of the sire's dam serve as an index of the breeding ability of the sire. Furthermore, the egg production of the three nearest female ancestors has been shown to have no significant relationship to the egg production of the progeny.

The author concludes by stating that these observations do not discount the value of pedigree breeding which involves recording the ancestry of every bird in the flock because it is only when pedigree breeding is carried on that progeny testing can be employed, whereby progress may be achieved through the results secured from given matings. A.D.B.S.

Fat percentage of Milk affected by Feeding Fats.

N. N. ALLEN. (1934). *J. Dairy Sc.*, Vol. 17, pp. 379-95.

In this experiment the fat content of the milk of dairy cows was markedly increased when the fat content of the ration was increased by the feeding of butterfat, lard, tallow, linseed oil, cotton seed oil, corn oil, peanut oil, soy-bean oil or cocoanut oil.

This increase was secured regardless of the breed of the cows, stage

of lactation, level of production, or season of the year. It was due primarily to increased butterfat production, since the milk yield was influenced only to a slight extent except in the case of cocoanut oil, which appeared to cause a depression of milk yield when fed in large amounts. A period of 12 to 24 hours after the fat was fed elapsed before its influence became observable in the milk. Hitherto the general belief has been that the fat composition of the milk cannot be greatly altered by feeding and that it is primarily a genetic problem. This paper re-opens the question. A.D.B.S.

Gene; The Attack on the

T. S. Painter. (1934). *J. Hered.*, Vol. 25, pp. 464-76.

The chromosome is a small, rod-shaped body which is found in practically all living cells. It plays an important part in the transmission of hereditary characters. Previous work has shown that on the chromosome are located what are known as the genes. Every inherited character is governed by one or more pairs of these genes. The gene is thus the unit of hereditary mechanism. The genes are located in order along the length of the rod-shaped chromosome.

In the reproductive cells the chromosomes are squat, and it is very difficult to examine them properly under a microscope. Dr. Painter has discovered that in the cells of the salivary glands the chromosomes are very much elongated. They are stretched out, and in the photographs assume the appearance of long tape worms. Because they are so elongated, it is possible to examine them far more closely than has been the case hitherto. This paper deals with the results of the first careful examination of such elongated chromosomes.

Dr. Painter has found that the chromosome consists of an elongated, more or less cylindrical, rod, made up of material which, when subjected to a stain, does not take on much colour. Running across each chromosome may be seen a great variety of " bands." Some of these bands are broad and take on a deep stain. Others are narrow and may be made up of only a series of dots. Dr. Painter found that these different markings on the chromosomes were constant to a quite extraordinary degree, with the result that he was able to recognise the same element in the chromosomes of different individuals: he was thus able to follow a characteristic bit of chromosome as it moved about.

It is in the fruit fly called Drosophila that the greatest amount of work has been done in correlating external characters with genes located on the chromosome. The question to which he is seeking to find an answer is: " Where are the genes? Are they represented by the deeply staining material or by some other part of that region of the chromosome? "

So far as Dr. Painter has been able to show, the gene resides in that area of the chromosome covered by one, or part of one, band. There is no definite proof that they are part of any of the structures which have been seen in these bands. Since, however, the bands are obviously particulate, and are complex in their structure, it would appear logical to suppose that the genes are to be found in these bands. Actually, whether these tiny bands are the genes themselves or only the bearers of the genes is a matter of relative un-importance. The important thing is that they have been unveiled, so that the searching finger of science may probe a little further into the secrets of life. A.D.B.S.

Grading Meat.

J. Hammond and G. N. Murray. (1934). *J. Agric. Sc.*, Vol. 24, pp. 233-49.

Dr. Hammond has for many years studied the carcases at the Smithfield Show and has brought his keen mind to bear upon the economic and scientific problems involved. In this paper it is pointed out that small joints in carcases can be obtained not only by using smaller breeds killed at the same age, but also, probably more profitably, by killing the same breed at an earlier age. From the figures given, many examples may be seen of the value in price per stone of carcase decreasing with increasing weight to such an extent that the profit obtained would be greatly decreased if the value of the maintenance food during the time taken to attain the increased weight is taken into consideration.

There are interesting tables and diagrams which illustrate these points for sheep, pigs and cattle in regard to the different breeds of each.

From the genetic point of view, since the weight-price curves for carcases from the different breeds and types of sheep and pigs do not run parallel, owing to the different weights at which the different breeds mature, it would appear better to institute weight classes in carcase competitions at Shows rather than age classifications. The writers add that, since with beef there appears to be very little difference in price due to sex, it would seem that sex differences in classes might be eliminated, and in their place classes might be instituted for animals of different weights. They point out that such a system has been working satisfactorily with pork and bacon for a number of years and might, with advantage, be adopted also for mutton and beef.

In the lower weight classes the prevailing fault is a low proportion of muscle to bone, while in the higher weight classes the prevailing fault is a high proportion of fat to muscle. Thus the authors state it would appear that, for comparative breeds, the decrease in price with increase in weight is due to two factors: (1) to increase in the size of the joints, and (2) to increase in the proportion of fat with increasing weight of the carcase within the breed. A.D B.S.

Kinky Tail in Swine.

J. E. Nordby. (1934). *J. Hered.*, Vol. 25, pp. 171-4.

In this paper, Dr. Nordby adds another to the list of genetic abnormalities which he has discovered in pigs. The defect described in this paper is characterized by rigid angles in the tail of the pig. At birth it is evident as a distinct kink, and is to be distinguished from the rather permanent spirals that so often develop toward the extremity of the tail. For the most part the kinks are found near the end of the tail, but they are not exclusively confined to this region. These kinks are more flexible at birth than at maturity, and they vary in number. In some specimens there have been found as many as three kinks.

The angles produced are, for the most part, lateral. They may all be in the same direction or one may be to the right and the other to the left. Exaggerated cases are found in which there are three acute angles in the same direction, producing a pronounced hook in the tail. The kink is rigid and is the result of the permanent fusion of two or more adjoining caudal vertebrae. This defect is of scientific interest but not of great practical importance and does not appear to be associated with any physiological disturbance.

The author observed the frequent appearance of the defect in some closely bred strains of swine. The data he publishes identify it as a recessive.

A.D.B.S.

Mental Tests for Sheep Dogs.

E. S. Humphrey. (1934). *J. Hered.*, Vol. 25, pp. 128-36.

In 1924 at Fortunate Fields, Vevey, in Switzerland, an investigation was commenced dealing with the inheritance of the German Sheep dog. Special attention was paid to the inheritance of mental and behaviour traits. It was found necessary to analyse exactly the different characteristics which went to the constitution of the different types of mentality of the various dogs. A good example is given of a type of dog called a " hanger," this being considered to be a mental behaviour trait. Such dogs did not jump their high jumps as did non-hangers. The average dog takes a running jump at a fence of say 6½ or 7 feet, hits it about 5 feet up, crawls to the top and then jumps down the other side at once. Hanger dogs do the same until the top is reached, then they make a definite pause which may even necessitate a command to come down from the top of the jump. This hanging trait seemed to run in certain families. It is well illustrated by reproductions from cinematograph films. The non-hangers, when they descended, hit the ground with their front feet, took up the jar and, letting their hind feet pass well ahead, straightened out into a run. The hangers, on the other hand, hit the ground in the same position but failed to take up the jar. The spring was not there; their noses bumped the ground hard, with the result that their hind quarters were thrown out of balance and they had practically to roll into a running position in order to get away. This bump was so fast that the observers had not noticed it in the normal speed of action. Then a further study was made and it was found that the hangers, without exception, were dogs straight in the structure of their shoulders as compared to the lesser angles of the shoulders of the non-hangers.

This is an example of the interesting type of material which this paper contains.

A.D.B.S.

Mortality in the Egg.

F. B. Hutt and A. M. Pilkey. (1934). *Poultry Sci.*, 13, pp. 1-13.

Malpositions of the embryos of chickens in the eggs which were late hatched were examined. Six different malpositions were discovered and these are detailed. The question was reviewed in relation to the position of the egg in the incubator. The results suggest that there are stages of incubation when it is advantageous to have the eggs with the large ends up, and others when the horizontal position is preferable. Incubating with the large end up until the twelfth or fourteenth day should reduce the frequency of one of the malpositions. Thereafter the advantage would appear to lie with the horizontal eggs if three other malpositions are to be kept at a minimum. It would mean that the eggs would be turned in one plane for the first two weeks of incubation and in another during the last four days of turning. The writers state that it is probable that the lower embryonic mortality observed by several investigators when eggs were turned four to six times daily, compared with that resulting when eggs were turned only twice, may be to some extent associated wih the lowered frequency of malpositions.

There are a lot of other interesting points raised in this paper.

A.D.B.S.

Pedigree Shorthorn Cattle: A Highly Inbred Herd of

J. L. LUSH. (1934). *J. Hered.*, Vol. 25, pp. 208-16.

The champion county group of Shorthorns at the Club Show at the Iowa State Fair in 1931 came from the herd of Mr. Neal of Mt. Vernon, Iowa, and were remarkable for their likeness to each other. Only seven steers from this herd have been shown, but everybody has been struck by their uniformity. Prizes have been won at leading Shows, including the International at Chicago. To demonstrate their uniformity, the seven that won at the Des Moines Show did, at a previous Show, take the first seven places in a class of twenty-eight. The remarkable uniformity of this herd was brought to the notice of Professor Lush of Iowa, who discovered that since 1912 only one beast has been added to the herd.

In 1912 Mr. Neal bought a Shorthorn bull-calf called "Sultan's Banner." In 1915 another bull was purchased. However, the calves of "Sultan's Banner" were infinitely superior to any other, and it was decided to use a son of this bull, "Banner View," and to discard the bull bought in 1915, only three of whose daughters were retained in the herd. The breeding history therefore is that of a herd practically entirely closed to outside blood since 1912.

Naturally there has been a very high degree of inbreeding employed in the maintenance of the herd. The relationship of the present herd to the present bull in use—"Banner"—is distinctly higher than if he averaged being a sire or full-brother to all of them. This bull has now been used so extensively that all the herd is closely related to him, and the next bulls to be used must be his sons. Hence, in the next generation the amount of inbreeding will increase even more than it is just now. The bull seems to be a good individual himself, and his progeny have proved that he has an unusually desirable hereditary constitution.

The owner has expressed the interesting point of view that he hesitates to look up the pedigrees of most of his animals lest on the one hand he become frightened by the amount of inbreeding that might be there or, on the other hand, that he might become so intrigued by some rule or system which he thought he saw that he would begin to follow this system and mate his animals by pedigree rather than by individuality. This statement is the key to one of the reasons for the success of this instance of inbreeding.

In the first place the foundation bull and some of the cows were definitely above the average. In the second place there has been rigorous selection on economic grounds, regardless of fancy points. The breeding policy was not deliberately planned but developed incidentally in an effort to conserve the good qualities of an outstanding sire. This is a practical demonstration that a moderate sized herd may follow a policy of intense inbreeding, maintain quality, and even improve upon it, with the result that all the animals become nearly as like to each other as ordinary full-sisters. A.D.B.S.

Progeny Test for Dairy Bulls.

B. L. WARWICK and O. C. COPELAND. (1934). *J. Hered.*, Vol. 25, pp. 177-81.

There seems to be no end to the writings concerning the value of the progeny test as a means for the improvement of dairy cattle. In this

paper, the authors consider that the best way of testing a bull is to mate him to low yielding cows, since this would require fewer progeny in order to give the same information as do tests when the daughters are out of average or high producing cows. Actually the value of the sire would be estimated on the minimum average and maximum production of his various daughters out of the low producing dams. A bull tested on this plan would be considered excellent if his daughters included none much below " average " and whose " average " hovered close to the mid-point between their dams' average production and the maximum of the breed. The authors consider such a test with twenty-twenty-five daughters as of more moment than that of a bull bred to good producers and having twenty-five daughters averaging somewhat more than their dams, even if a record producer were included in the list. They state that even twenty-five daughters is far from enough to prove whether a sire is homozygous for the qualities of high milk production.

Twenty-five daughters implies that a young bull must be mated to at least fifty low producing cows in order that an estimate of his quality may be obtained before he is five years old. This sounds quite beyond the limits of even the pedigree breeder. The writers, however, state that it should be possible to maintain a test herd of this nature at a relatively low cost. Low-producing " boarder " cows from herds of the same breed might be used. Such cows would be run as a beef herd, and the bull to be tested would be run with them. When the calves are dropped the bull-calves would be disposed of for veal and their dams would be dried off and re-bred. The heifer calves would be allowed to suckle their mothers while on pasture, thereby eliminating much of the labour incident to calf raising. When the heifers come into their first lactation they should be well fed and milked, and this initial record would show " rather definitely whether the heifer has the ability to respond."

In theory there may be a lot to be said for this procedure, but even for a large pedigree breeder it would hardly appear practicable.

A.D.B.S.

Progeny Testing of Dairy Bulls.

JAMES MACKINTOSH. (1934). *J. Brit. Dairy Farmers' Assoc.*, Vol. 46, pp. 11-31.

To Mr. James Mackintosh of the National Institute of Research in Dairying at Reading goes the credit for being the first amongst the more modern of Agricultural Advisers to advocate the progeny test as a means for the improvement of the productive qualities of our dairy cattle. In 1920 he contributed an article on this point to the Journal of the Ministry of Agriculture and illustrated it by the milk yields of the daughters of two bulls which had been used in the Dairy Shorthorn herd of the University of Reading. This article consists of a presentation and discussion of information on the progeny test collected from the records of the Institute's herd from 1920-1933. Altogether the progeny of four bulls are available for study. The yields were corrected for age, etc.

One important point concerning the results of the various progeny groups of the different bulls is an illustration of the fact realised by many breeders that the rate of maturing of the progeny of one bull

is different from that of another. Thus the actual mature yields of the daughters of one bull were some 16 per cent. higher than the yields as calculated by the use of the correction factors. The logical conclusion from these results is that slightly different correction factors should be used for the progeny of each bull. This, however, is impracticable and the author states that correction factors applied to the first lactation yield of one heifer may be seriously misleading.

Another point of practical importance in the working out of the progeny test is the number of daughters required to give a reliable indication of the value of a bull. Looking at the question from a statistical point, it has been agreed that six daughters constitute the minimum number. The progeny of the various bulls have been grouped, under each bull, in lots of six. With the bull having the largest number of daughters, the first lot of six gave actual milk yields of daughters averaging 716 gallons. The second lot of six averaged 654 and the third lot 548. The average for the thirty-two daughters was 618.

With the help of his colleague, Mr. Bartlett, the author has attempted to determine how much is the difference between the average yields of the progeny of the different bulls that would be significant in the event of comparing the bulls. So far as the milk yields are concerned, the differences between the averages of the first sections of six daughters from each bull given in an accompanying table might be due to chance, and do not prove convincing evidence that any one bull employed in the herd during this thirteen year period was definitely superior or inferior to the others. Accordingly, the author states that other qualities possessed by the progeny, such as fat percentage of the milk, shape and wearing qualities of the udder, breed type, etc., would be the deciding factors.

It is held by many that the yields of the daughters of a bull depend, to a considerable extent, upon the yields of the cows with which that bull is mated. The results show that the daughters of one bull show a considerable increase of 124 gallons in the actual milk yield of the heifers and of 174 gallons in the mature milk yields over the yields of the dams of these heifers. As regards the heifers' milk yields of the other bulls, decreases are marked, varying from 22 to 88 gallons. One other bull has an increase of 48 gallons in the yield of his daughters over that of their dams. The writer concludes that the comparison between the yields of six daughters and that of their dams, while supplying interesting information, is not essential to the interpretation of a progeny test. On the figures stated above there are scientists and breeders who will find it difficult to agree with this conclusion. Much remains to be discovered concerning the progeny test and Mr. Mackintosh is to be congratulated on his contribution to the subject.

A.D.B.S.

Riggs in Pigs.

H. C. McPhee and S. S. Buckley. (1934). *J. Hered.*, Vol. 25, pp. 295-303.

Cryptorchidism is the condition which results from the failure of one or both testicles to descend into the scrotum of a male animal; when both testicles fail to descend the animal is called a bilateral cryptorchid and when only one testicle is retained in the abdominal cavity the

animal is said to be a unilateral cryptorchid or to exhibit the monorchid condition. Cryptorchidism occurs in all farm animals, but appears to be most common among horses and swine. It is regarded as a most undesirable character since there is a widespread belief that cryptorchids are sterile.

The material for this study consisted of an inbred strain of Chester White pigs which was being developed by continuous brother x sister matings, coupled with selection, in order to establish a herd in which would be combined in the homozygous state as many desirable characteristics as possible. Hence the data collected on the inheritance of cryptorchidism occurred only incidentally. The foundation stock for this inbred strain comprised four litter-mates, three sows and one boar (one of the sows produced only one litter, of which none of the piglings were used subsequently) in the ancestry of which there was no record of the occurrence of cryptorchidism. Five generations of brother x sister matings were considered and the incidence of cryptorchidism carefully analysed.

The authors review the facts published in the literature and point out that, while several writers have concluded that the condition is inherited, very little scientific evidence has been advanced in support of this conclusion, and exact details of the mode of inheritance have not been determined. Unfortunately, however, their own results, while indicating that the defect is definitely inherited, do not advance our knowledge of the type of inheritance involved to any great extent since the data are not sufficiently complete to form a basis for more than speculation with regard to certain points.

To sum up, the authors assume that cryptorchidism in pigs is a sex-limited recessive character, capable of explanation in the majority of cases on a single factor basis; they suggest that some cases may occur which are not hereditary. They further assume that the unilateral and bilateral types are controlled by the same genetic constitution. They emphasise that the only way in which the condition can be eliminated is by discarding all sows and boars known to have produced cryptorchid offspring, and point out that even with such rigid elimination the defect may appear from time to time, owing to the difficulty of detecting heterozygous animals by breeding tests.

On occasion it is possible that a bilateral cryptorchid boar may be temporarily fertile at a certain period of the year, but generally speaking these are infertile animals. The unilateral type of cryptorchid is usually reasonably fertile, but since this paper shows that the two types are obviously associated, then there is a clear danger in breeding from boars which have only one descended testicle. The writers strongly urge that cryptorchids should never be used as sires.

This is an important paper since it traces quite clearly the inheritance of this defect in one of the larger farm animals. That the condition is hereditary in horses, there can be no dispute, but the method of inheritance in the equine race has not been so clearly demonstrated. From this paper, one can deduce that it is not sound practice to breed from riggs. A.D.B.S.

Sex Control Again.

L. J. Cole and I. Johansson. (1933). *J. Hered.*, Vol. 24, pp. 265-74.

" Among perennial announcements that occur, particularly in the popular press, are the discovery of the ' germ ' of cancer, cures for

tuberculosis, and methods for the control of sex. If cancer is caused by a germ it no doubt will sometime be discovered; it is not improbable that a specific cure for tuberculosis may some day be found; and sex of offspring will be under control just as soon as someone discovers a method of effectively separating the male and female-producing spermatozoa, thus determining which shall fertilize the egg."

So state the authors in the opening sentence of their paper to which they have been provoked by a number of announcements in the Daily Press of the United States. The latest vogue in methods for the determination of sex in that according as the vagina is more alkaline, so there is a greater chance for males to be produced. This has led to the washing of the vagina with a weak solution of sodium bi-carbonate and, when females are desired, the use of lactic acid. This theory does not stand any more critical examination than do many previous theories of sex control.

The present writers ran a limited experiment with swine to test the possible effects of alkalinity on sex ratio. They were unable to affect the sex-ratio, but they did decrease the fertility of the sows.

The outstanding fact with regard to sex determination is that, in mammals there are regularly two types of spermatoza. One of these types bears an X-chromosome and the other bears a Y-chromosome. Both types are normally produced in equal numbers. The eggs are all of one sort, each with an X-chromosome. The sex of an individual depends on whether the egg is fertilised by an X-bearing or a Y-bearing spermatozoon. In the former case the result is a female and in the latter case a male.

Countless theories of sex determination for sex control have been proposed but they have done more credit to the imagination of the proposers than to their scientific acumen. At the same time it must be recognised that the sex-ratio both in man and animals is subject to variation and that little is known as to the cause of these variations. There is no doubt that some day the sex will be brought under control. But that day has not yet arrived. A.D.B.S.

Type Studies of Pigs and Economy of Liveweight Gain.
(1933). *Report of the Chief of the Bureau of Animal Industry, U.S. Dept. of Agric.*

Work at Beltsville has been on the small, intermediate and large type of Poland China hogs. In spring, 1932, five small type sows farrowed litters averaging 4.2 and weaned an average of 2.0 pigs. Six intermediate type sows farrowed an average of 6.7 pigs and weaned 5.8. Five large type sows farrowed an average of 6.8 and weaned 5.4 pigs. Pigs from the three types of sows were fed in separate groups from weaning to approximately 225 lbs. Food was utilized most efficiently by the pigs of large type parentage. The intermediate and small types followed in order.

Twelve litters of the spring of 1932 and seven litters of fall farrow, the same year, were tested in connection with performance studies at Beltsville. Four pigs were used to represent each litter. They were on test from seventy-two days of age until they reached a final weight of approximately 225 pounds. The variation in average daily gain for the twelve groups of spring pigs was from 0.56 to 1.41 pounds. Feed consumed per 100 pounds gain ranged from 360.7 to 508.6 pounds. The

seven groups of fall pigs ranged in average daily gain from 0.98 to 1.68 pounds, whereas the feed consumed per 100 pounds gain ranged from 386.2 to 396.1 pounds. Wide differences in efficiency of production were associated with differences in breeding among the groups. The importance of basing selections of breeding animals on progeny tests is emphasized by these results.

Analysis of data from a series of tests conducted at Miles City, Mont., shows that gilts from gilts farrowed an average of 7.7 pigs, gilts from old sows, 8.9 pigs, and old sows 10.2 pigs. The respective percentages of pigs weaned were 72.7, 76.5, and 61.9. The pigs from each of the three groups of sows were fed under uniform conditions to a market weight of approximately 200 pounds. During this feeding period the pigs whose dams were gilts from gilts made an average daily gain of 1.85 pounds, those from gilts from old sows 1.43 pounds, and those from old sows, 1.40 pounds. The respective quantities of feed consumed by the pigs per 100 pounds gain were 382.8, 399.2, and 416.7 pounds.

Other factors than those mentioned above are involved in the selection of sows for the breeding herd. However, the results indicate that the use of gilts from gilts is not so satisfactory as the use of the other two groups of sows. A.D.B.S.

Supernumerary Teats in Cattle.

W. GIFFORD. (1934). *J. of Dairy Sc.*, Vol. 17, p. 559.

Butterfat of Cows with Supernumerary Teats.

W. GIFFORD. (1934). *J. of Dairy Sc.*, Vol. 17, pp. 571-3.

It is not uncommon to observe cows which have, in addition to the four normal teats, a variable number of additional teats, some of which are connected to small glands, others may be without glands, while yet others may open into one of the normal glands. There is a general tendency for cattle breeders to look upon multi-nippled udders with disfavour. Certain breeders do, however, believe that this quality is associated with high milking properties.

The present investigation was on various herds in Missouri. In general, three types of supernumerary teats were found, as follows.—Caudal, or those found at the rear of the normal; Intercalary, or those found between the normal teats; and Ramal, or the supernumeraries which are ramifications and branches of normal teats. By far the largest number of cases found were the caudal type, only comparatively few intercalary and ramal being obtained.

Of the 1,249 cows exhibiting supernumerary teats, 94 per cent. possessed one or more caudal teats. This constituted 24.5 per cent. of all the cows observed. Against this, only 14 per cent. of the bulls examined had one or more supernumerary teat. This paper reviews the work of other writers.

In his second paper, Dr. Gifford deals with the question of the relationship of supernumerary teats to butterfat production, and comes to the conclusion that it seems that the factors for the capacity for high butterfat production are not closely linked with the character of supernumerary teats. From the practical viewpoint, he states, there is no indication that supernumerary teats are external traits indicating ability superior to the normal condition for butterfat production.

A.D.B.S.

Twins in Horses.

B. J. Errington and W. L. Williams. (1933). *Cornell Veterinarian*, pp. 354-61.

This paper deals primarily with the physiological aspect of the placentation of equine twins. It is well known that the mortality of equine twins enormously exceeds that observed in any other mammal. One of the writers has recorded that in one year in a stud of twenty-six pregnant mares there were six twin pregnancies and that as a rule twinning mares have mostly failed to breed again. There are, however, exceptions. Every horse breeder knows of one or two cases where the twins have been born alive and the foals have been raised.

As a rule equine twins are grossly unequal in size, far more so than is the case in any other known species. The reason for this can be explained on the study which the authors have made. In technical language it is accounted for as follows:—

The invaginating ovum, deprived of adequate endometrial contact, inevitably becomes dwarfed and its defective nutritive supply lowers its resistance and endangers its health and life. Without chorionic fusion, as in ruminants, the invaginating ovum cannot obtain parasitic nutrition from its enveloping mate.

Individuals of equine twins show wide variations in their power to resist disease. In ruminants if one of a pair of twins dies, the other frequently perishes. Since equine twins possess separate chorions, they do not commonly die sumultaneously.

Available data indicate that most equine twins are males, perhaps in the neighbourhood of about 150 males to 100 females, but the ratio of abortions with males along with early deaths, serves to equalize the sex-ratio and may end in an excess of fillies. A.D.B.S.

Woolly Hair in Swine.

A. O. Rhoad. (1934). *J. Hered.*, Vol. 25, pp. 371-5.

A woolly haired pig has woolly hair over its body. In the new-born pigs, the crinkly condition is not so pronounced as in older pigs, though the woolly-haired individuals can be fairly easily distinguished from their normal straight-haired brothers and sisters. The pigs reported here were found in Brazil. Native Brazilian animals were mated to each other and to Duroc Jersey and Poland China boars. The results of six matings gives some evidence that woolly hair in swine is due to a single mendelian factor, completely dominant over normal straight hair, which is the recessive condition. The factor appears to be independent of coat colour, coat pattern or sex. A.D.B.S.

SOILS AND MANURES.

Abstractor:

Rice Williams, M.Sc., University College, Bangor.

Calcium Cyanamide as a Nitrogenous Fertiliser.

T. R. Moyer, *Soil Sci.* (1934), 37, 4, 305-30.

Experiments at the New Jersey Experiment Station showed that calcium cyanamide, properly applied, gave crop yields equal to those produced by equivalent amounts of sodium nitrate, ammonium sulphate

and urea. In very acid soils under conditions that did not allow leaching, calcium cyanamide was not quite as good as sodium nitrate but was definitely superior to ammonium sulphate in yield of dry matter and recovery of nitrogen. The nitrogen from calcium cyanamide was not leached out of the soil as readily as that from sodium nitrate or from ammonium sulphate. It is pointed out that the high percentage of calcium in calcium cyanamide produces a beneficial effect on the physical properties and upon the H-ion concentration of the soil. The use of pulverised calcium cyanamide to destroy weeds in grassland or small grains is discussed. It should be applied in the early spring and in the morning while the dew is still on the plants. R.W.

Compost Manure.

A. W. R. JOACHIM. *Ceylon, Dept. Agric. Ann. Rept.* (1934).

Experiments with night soil composts showed that night soil was better as a starter than as the main ingredient of composts. It was found that successive small doses (2 per cent.) of night soil made better composts than large single doses (12½ per cent.) The addition of lime caused heavy losses of nitrogen and organic matter. It is suggested that the heaps should be left uncovered and turned weekly. R.W.

Cyanamide and Certain Other Nitrogenous Fertilisers on Various Iowa Soils; Some Chemical and Biological Effects of.

M. H. BROWN. *J.Amer. Soc. Agron.* (1934), 26, 5, 442-50.

Applications of cyanamide and sodium nitrate decreased the acidity of the soil as measured by pH, while ammonium sulphate and commercial ammonium phosphate caused an increase in the acidity. Cyanamide caused a marked increase in the soluble phosphorus content of the soil, whilst equivalent amounts of sodium nitrate or ammonium sulphate had no effect. None of these fertilisers exerted a marked effect on the nitrate accumulation or on the ammonifying and nitrifying of the soil. Applications of superphosphate, however, brought about some increase in biological activity. R.W.

Green Manures in Soil; The Decomposition of.

J. A. DAJI. *J. Agri. Sci.* (1934), 1, 15-27.

Plant materials of widely different origin and age were used as green manures mixed with soil for decomposition studies under laboratory conditions. Under optimum conditions the decomposition depends upon the chemical constituents of the plant material. The soluble carbohydrates, hemicelluloses and cellulose are mainly responsible for the loss of total organic matter during decomposition. Materials containing excess of nitrogenous compounds decompose most rapidly whilst those containing excess of carbohydrate show a slower rate of decomposition. Thus young plant materials by virtue of their abundance of available nitrogenous compounds decompose more quickly than mature tissues. When comparatively young plant materials are used there is danger of a loss of nitrogen, the loss depending upon the total and available nitrogen they contain. R.W.

Green Manuring; Investigations on the Effect of.

E. A. MITSCHERLICH, W. SAUERLANDT and A. KUHNKE. *Landw. Jahrb,* 1934, 79, 941-75.

Experiments comparing the effects of farmyard manure and green

manuring show that farmyard manure produced more lasting results than green manuring. After a few months the nitrogen content of plots which had been heavily green manured had been reduced to nearly the same level as that of the unmanured plots. The experiments confirmed the conclusions arrived at by Löhnis that the effect of green manuring on soils was mainly due to the effect of leguminous plants.

R.W.

Mono-, Di-, and Tricalcium Phosphate on the Reaction of Soils of Different Degrees of Acidity; The Effect of.

W. H. PIERRE. *Soil Sci.*, 1934, 26, 4, 278-89.

The effect of six different phosphates on the reaction of three soils of different degrees of acidity (pH) and kept moist was studied over a period of eighteen months. The changes in acidity after six weeks and after eighteen months were determined. It was found that the original reaction of the soil materially influenced the effect of the various phosphates on soil reaction; the more acid the soil, the greater the basic action of the different phosphates or the less their acidic effect.

It is concluded from the results that for most soils of the humid regions, the pH values of which lie mostly between five and six, superphosphate, rock phosphate, and monocalcium phosphate can be considered to have no appreciable effect on soil reaction, whereas hydrated dicalcium and tricalcium phosphate can be considered basic. R.W.

Potassium Deficiency on the Composition of the Tomato Plant; The Effect of.

T. G. PHILLIPS, T. O. SMITH, R. B. DEARBON. *New Hampshire Sta. Tech. Bull.*, 1934, 59.

The effect of potassium deficiency in the early stages of deficiency were studied by the analysis of plants grown in nutrient solutions. The deficient plants were lower in ash, percentage dry matter, and phosphorus than the plants receiving a complete nutrient solution. They were also higher in solids, reducing sugars, and insoluble nitrogen as compared with those receiving the complete nutrient solution. The determinations gave no evidence of deranged nitrogen metabolism at this early stage of potassium deficiency. R.W.

Superphosphate in Calcareous Soils; The Effect of Depth of Placement on the Availability of.

R. D. HOCKENSMITH, R. GARDNER and A. KEZER. *Soil Sci.*, 1933, 36, 1, 35-9.

Experiments on the effect of the depth of placement of superphosphate on the growth of lucerne were carried out in five gallon jars. It was found that the depth of application made a marked difference in the yield. At half-an-inch below the surface there was no marked significant difference between the treated and untreated, whilst at one inch below surface there was over 100 per cent. gain over the untreated. A further gain was observed at four inches, but no significant difference was found when equivalent amounts of phosphate were placed at four inches and six inches below the surface. It is suggested that the failure to obtain a profitable response to superphosphate in some calcareous soils may be due to improper placement of the fertiliser.

R.W.

Urine as a Manure; The Value of.

E. Truninger and F. Keller. *Landw. Jahrb. Schweiz*, 1934, 95-131.

Fresh urine was found to be more effective on grassland than fermented urine, especially on poor acid soils. The difference was less noticeable on calcareous soils. A harmful effect was associated with the production of hippuric acid on fermentation. R.W.

AGRICULTURAL BOOKS, 1934.

The following list, prepared by the staff of the National Library of Wales, is a selection of the more important books on the science and practice of Agriculture published during the year 1934. The list supplements *The Hand List of Books on Agriculture* issued by the National Library, *third edition*, 1926, copies of which can be obtained on application to the Librarian, The National Library of Wales, Aberystwyth.

BRITISH SCIENCE GUILD. Some problems of British forestry, by R. S. Troup. London: The British Science Guild, 1933. pp. 16 ... ... 1s. 0d.

BROWN, E. T. The Poultry-Keeper's text-book . . . *2nd ed.* London: Ward Lock, 1934. pp. 320. front., ill., fdg. pl., diags. ... ... 6s. 0d.

BULLOCK, W. Timber from the forest to its use in commerce. London: Pitman, 1934. pp. x, 162. front., ill. ... ... 8s. 0d.

CANE, P. S. Garden design of to-day. London: Methuen, 1934. pp. xvi, 222. front., pls. ... ... 15s. 0d.

CROWTHER, E. M. Soil and fertilisers . . . Repr. from the *Reports of the Progress of Applied Chemistry*, Vol. XVIII, 1933. Cambridge: Heffer, 1934. pp. 519-552. bibl. ... ...

DUNKIN, H. The Pruning of hardy fruit trees. London: Dent, 1934. pp. xiv, 82. diags. ... ... 5s. 0d.

GRAINGER, J. Virus diseases of plants. Oxford University Press, 1934. pp. viii, 104. pls., diags., bibl. 6s. 0d.

HANSON, C. O. Forestry for woodmen . . . *3rd ed.* Oxford: Clarendon Press, 1934. pp. 288. front., pls., ill. ... ... 6s. 6d.

HENNELL, T. Change in the farm . . . Cambridge: University Press, 1934. pp. x, 202. ill. ... ... 10s. 6d.

IRVINE, F. R. Text-book of West African agriculture. Oxford: University Press, 1934. pp. xii [iv], 348. ill., diags., bibl. ... ... 7s. 6d.

JERSEY. *Royal Jersey Agricultural and Horticultural Society.* One hundred years of the Royal Jersey Agricultural and Horticultural Society, 1833-1933. Compiled from the Society's records by H. G. Shepard. Jersey: [The Society], 1934. pp. 96 ... ...

LE SUEUR, A. D. C. The Care and repair of ornamental trees in garden, park, and street. London : Country Life Ltd., 1934. pp. xiv, 258. front., ill., bibl. ... ... 10s. 6d.

LEWIS, H. R. Productive poultry husbandry . . . *8th ed. rev.* Chicago : Lippincott, 1933. pp. xliv, 588. col. front., ill., bibl. ... ... 12s. 6d.

LINTON, R. G. Veterinary hygiene . . . *2nd ed.* Edinburgh : Green, 1934. pp. xx, 472. ill., diags. *Edinburgh Veterinary Series.* ... ... 21s. 0d.

LONG, H. C. Weed suppression by fertilizers and chemicals. Surbiton, Surrey : The Author, 1934. pp. 58, ill. ... ... 2s. 0d.

MCINTOSH, D. C., *and* ORR, D. M. *Editors.* Agriculture for secondary schools [by various authors]. New York : American Book Co., 1934. pp. x, 486. front., pl. (port.), ill., diags., bibl. ... $1.0

MACSELF, A. J. Editor. The Gardener's enquire within . . . *4th ed. rev.* London : Collingridge [1934]. pp. 640. front., ill., diags. ... ... 7s. 6d.

MILLER, W. C., *and* ROBERTSON, E. D. S. Practical animal husbandry. Edinburgh : Oliver and Boyd, 1934. pp. xvi, 316. front., pls., ill., bibl., diags. ... 12s. 6d.

MÖNNIG, H. O. Veterinary helminthology and entomology : the diseases of domesticated animals caused by helminth and anthropod parasites. London : Bailliere, Tindall and Cox, 1934. pp. xvi, 402. pls., diags., bibl. ... ... 30s. 0d.

OXFORD : *University. Agricultural Economics Research Institute.* British sugar beet : ten years progress under the subsidy. By A. Bridges and R. N. Dixey. Oxford : The Institute, 1934 ... 2s. 6d.

———The Planning of Britain's food imports : a quantitative study of the effects of recent legislation, by K. A. H. Murray and R. L. Cohen. Oxford : The Institute, 1934 ... ... 3s. 6d.

———Progress in English farming systems. VIII. Pioneers in power farming, by C. S. Orwin. Oxford : The Institute, 1934. pp. 26. front., pls. ... ... 1s. 6d.

ROBERTSON, C. J. World sugar production and consumption : an economic-geographical survey. London : John Bale, Sons and Danielsson, 1934. pp. viii, 142 ... ... 5s. 0d.

ROHDE, E. S. Gardens of delight. London : Medici Society, 1934. pp. xii, 308. front., pls., ill. ... 15s. 0d.

STEBBING, M. E. Colour in the garden . . . London : Nelson, 1934. pp. viii, 112. pls. (some col.). ... 12s. 6d.

STEWART, T. J. Notes on milk. London : Lewis and Co., Ltd., 1934. pp. 46 ... ... 1s. 6d.

STEYN, D. G. The Toxicology of plants in South Africa . . . South Africa : Central News Agency, 1934. pp. xii, 632. ill., bibl. ... ... £2 7s. 6d.

STONE, A. A. Farm machinery . . . *2nd ed.* New York : Wiley, 1934. pp., xii, 466. ill., diags. ... 18s. 6d.

STREET, A. G. Farmer's glory . . . London : Faber and Faber, 1934. pp. 318. Wood-engravings ... 8s. 6d.

WATSON, J. A. S. *and* MORE, J. A. Agriculture : the science and practice of British farming. Edinburgh : Oliver and Boyd, 1933. pp. x, 778. pls., ill. ... ... 15s. 0d.

WETHERED, H. N. A short history of gardens. London : Methuen, 1933. pp. xvi, 324. front., pls. ... 12s. 6d.

WILLCOX, O. W. Reshaping agriculture. New York : Norton and Co., 1934. pp. 158 ... ... $2.0.

WOODWARD, W. A. The Countryman's jewel : days in the life of a sixteenth century squire (by W. A. W. Edit. by M. Woodward) London : Chapman and Hall, 1934. pp. xviii, 310. front., wood-engravings ... ... 15s. 0d.

WRIGHT, C. H. Soil analysis . . . London : Murby and Co., 1934. pp. viii, 236. diags., bibl. ... ... 12s. 6d.

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CONTENTS.

RURAL MIGRATION.

By W. H. Jones, M.Sc., and J. R. E. Phillips, B.A.,
University College, Aberystwyth.

One of the most conspicuous features of rural Britain during the last fifty years has been the decline of its population. The forces responsible for this are probably rather numerous, and they have exerted their effects in many ways. Urban areas have been increasing in size and cities have been growing partly because there was a natural increase in their populations and partly as a result of movements into them from rural districts. Some observers attach great importance to rural migration and maintain that it is undesirable that a perpetual drift of the farming population to the cities should occur. The problem, however, must be viewed from two angles, the economic and the psychological.

Again before any attempt is made to check the rural drift, it must be decided whether or not the effects are as disastrous as is sometimes maintained. Rural migration of itself cannot be wholly undesirable if the economic forces demand it, and ultimately, fair consideration must be given to the standards of living both in the country and in the towns. It may be true that some persons now living in cities would be better off on farms, but to place the unemployable town people on farms would not improve rural conditions.

In the Census reports populations are divided into "rural" and "urban" groups by administrative districts and there would therefore be included amongst the rural populations a considerable number of those who live outside the cities but who are not engaged in the agricultural industry. To understand the situation clearly, therefore, the agricultural population must be kept apart from the rural population, as many of the factors which affect the numbers of people engaged in farming are different in nature from those influencing the numbers of rural dwellers, but, of course, some are also common to both. Nevertheless a decline in the numbers of people on farms inevitably leads to a decay in some rural industries, and tends to cause a decline in numbers concerned with commerce and services in or near rural areas. Most of the village folk in one way or another are engaged in catering for the requirements of the farm population; smiths, carpenters and shop-keepers find it increasingly difficult to carry on their callings successfully when

the demand for their services or products shows a downward tendency in consequence of the decline in the agricultural population. Factors affecting the prosperity of farming, therefore, exert their influence upon certain classes of the rural population, especially those partly dependent upon the farming community for the successful prosecution of their businesses; but it is apparent that the number of people on farms declined to a greater extent than the number living in rural districts in each decade since 1871.

British agriculture has been affected in a particular way by the movement towards the industrialisation of this country. In fact most western countries have experienced somewhat similar changes in the relationship between agriculture and industry. Some have suffered an almost complete transformation of economic organisation and simultaneously in the equilibrium between the urban and rural population. Industrialisation has affected rural industries also, most of the commodities required by farmers are now made in factories and not in local work-shops as was formerly the case. This has exerted its influence upon the rural population almost independent of its effect upon agriculture. Industrialisation has meant the introduction of the factory system for the production of many commodities other than food. With the aid of mechanical power, standardised methods, large business units and the division of labour, industrial products have been placed on the market in large quantities and at comparatively low prices. This has again driven the farming community towards greater dependence upon the sale of food than was the case when a fair proportion of their requirements were made on the farm or at the local village.

The mechanisation of agriculture has proceeded during the last fifty years at an increasing pace. But this occurred at a more rapid rate in the newer countries of the world, as in the opening up of new regions farmers were not handicapped with farms which had been set up and equipped to meet entirely different conditions. British agriculture, therefore, during the last half century, has been subjected to the effects of industrialisation in this country and to opening up of new food producing regions in the world.

Ultimately production in industry and in agriculture must bear a definite relation to one another. There exists in this country a demand for a certain quantity of food; a quantity which may vary within certain limits; but it is upon the non-agricultural population that farmers rely for a market in which to dispose of the greater part of their commodities. The area

from which that quantity is supplied has been gradually widening and it expanded with great rapidity during the last half century.

With the development of transport facilities certain areas of food supplies expanded and the products from virgin soils and from favourable climates were entering into very effective competition with home products. In many oversea countries food could often be produced at comparatively low cost; the land carried much lighter financial burdens; necessary outlays being somewhat low, there was an encouraging prospect for enterprising individuals to undertake its development.

Emigration, therefore, is a factor which played some part in the movement of population. It may have been a movement within the industry, although it was out of British agriculture. The Trade Union movement amongst agricultural workers in this country between 1871 and 1881 accelerated emigration to some extent. It was used by the leaders as a weapon in an attempt to raise wages and improve the conditions of work and life of the agricultural labourers. Some financial assistance was given to folk who left for the Colonies, but although some were encouraged to leave British agriculture at the time, under the stimulus of this movement, it cannot be said that its influence was widespread or that it had an appreciable effect upon the numbers engaged in the agricultural occupations of this country.

These two forces, therefore, have exerted their effects upon the agricultural population of this country; the competition of industry and of agriculture in other countries. In general, both of these could offer greater opportunities and higher incomes than could home agriculture. Industry is generally organised in such a way that much of the heavy routine work can be relegated to machinery. The use of mechanical power raises the productivity of each workman and enables higher wages to be paid. Up until the end of the War the demand for industrial labour both in this country and in others was expanding except for minor set-backs in years of industrial depression. There was no reserve of idle labour to be drawn upon to meet the requirements of new industries or of development of the older ones. Periods of industrial activity therefore created a demand for labour, and when the supply was short wages were frequently offered at levels which proved attractive to the low paid agricultural labourer.

In recent decades conspicuous changes have occurred in the numbers of people leaving our shores for other countries, and this has had an appreciable effect upon the numbers engaged in British agriculture. In the pre-war years an appreciable number of the people leaving for the non-European countries were drawn

from the rural areas and were proceeding to the new countries with a view to taking up agriculture. There was, in fact, a rather steady movement from the British countryside to the open spaces of the newer countries. It was a movement within an industry and led to the development of agriculture in those countries, and as farming was generally one of the first industries to expand, the products raised gradually entered into competition with our own commodities. These regions were often able to produce foodstuffs at comparatively low cost and place them on the market at prices with which the British farmer could not compete. The decline in the prices of some cereals and animal products during the closing decades of the last century indicate the influence that emigration eventually had upon our agriculture.

It must not be inferred, however, that the emigrants mainly emanated from the country, large numbers of non-agricultural workers left our cities for the industries of other countries. The high wages offered in such countries as the U.S.A. attracted large numbers, and when restrictions of emigration were absent, there was somewhat of a free flow from our industrial regions to the factories of other countries. In the post-war period, however, emigration has been curtailed and only limited numbers are allowed to enter, the Quota regulations have, therefore, prevented the movement of workers from comparatively poor paid occupations in this country to other countries where wages are higher. The effects of such measures have been many : the flow of commodities from the new countries to our own was not interfered with until about three years ago; on the other hand restrictions on the movement of people have been in existence for many years. Foodstuffs were being placed on our markets in increasing quantities and at prices which proved unremunerative to our farmers. The continued flow of food from abroad compelled many farmers in this country to turn to the production of commodities which were not subject to intense overseas competition or caused workers to leave agriculture for the cities.

The pressure of food supplies from abroad depressed agricultural prices, some branches of farming became unremunerative and were curtailed, yet the opportunities afforded to the population to leave their calling and pursue others had been severely restricted. Emigration was only possible on a limited scale; on the other hand our cities were suffering from the falling price level of industrial goods. The rationalisation of industries resulted *inter alia* in permanent industrial unemployment, in consequence the demand for labour in the towns could be met by their own people, and there was no need to take people from

the countryside as had been the case in pre-war decades. Therefore, two forces which, in earlier years, had caused rural depopulation were, in the years after the War, working in the opposite direction and helping to maintain our rural population. The closing of doors to emigrants in the new countries and the abundant supply of industrial labour available were new phenomena. After 1931, in fact, the number of people returning to this country was larger than the number leaving. The industrial depression in the U.S.A. partly accounted for this. In the years immediately following the War large numbers from this country migrated on account of the high wages available. The depression after 1930 resulted in many of them returning to the mother country.

The population of the 1,120 urban areas of England and Wales amounted to 31,948,000 in 1931, while that of the 638 rural areas amounted to 7,999,000. The proportion living in urban and rural areas in that year was 80 per cent. and 20 per cent. respectively. A persistent decline in the proportion under rural administration has occurred during the recent decades; in 1871 almost a third of the population lived under rural conditions, but by 1931 it is seen that the proportion had fallen to one fifth. The migration of rural population during the closing decades of the last century was far more rapid than that which occurred subsequent to 1901. The labour demands of new industries drew large numbers of men from agriculture and from the countryside to the towns. The increase in urbanisation during this century can be partly explained, however, by the expansion of the urban centres themselves. The natural increase in the population of the cities led to increasing pressure upon the space available. This pressure became more intense as the towns grew in size until they were obliged to expand into the suburban regions. Between each census year our towns had encroached upon the adjacent territory as their boundaries extended.

The widespread building activities of the last decade or so have further extended the towns into regions formerly rural and large areas in close vicinity to the towns, included as rural in one census year, became part of urban areas in the subsequent one. There has been, therefore, some decentralisation of the towns—a migration towards the outskirts, and when the boundaries of the administrative areas also changes there occurs an important decline in the size of the rural areas and also in the rural population. This movement occurs quite independent of the migration of people from agriculture, and a study of the rural population is in consequence rather different from that of the

agricultural population. When towns expand into sub-urban regions or when new industries take advantage of the cheaper land available in the country (and no compensating change is made in the administrative districts) there is, of course, accession to the rural population due to the activities of industry. It is necessary, therefore, to study the rural and urban areas when allowance has been made for the change of boundaries. The natural growth in any decade of both urban and rural populations would be that achieved exclusive of alterations of boundaries of areas. Taking the rural and urban populations in each censal year as they would have been, had there been no alteration of boundaries within the decade, the following percentage change appears :—

Year.	*Rural.*		*Urban.*	
	No boundary alteration.	*Boundary alteration.*	*No boundary alteration.*	*Boundary alteration.*
1891	+ 3.0	— 5.8	+ 15.4	+ 8.1
1901	+ 2.9	— 10.8	+ 15.2	+ 4.7
1911	+ 10.2	— 4.8	+ 11.1	+ 1.8
1921	+ 4.3	— 5.0	+ 5.2	+ 1.4
1931	+ 7.8	— 5.9	+ 4.9	+ 1.5

It is seen therefore that had the boundaries remained unchanged the rural population would have shown an appreciable increase and, that in fact, the rural development was proceeding at relatively the more rapid rate. When, however, cognizance is taken of the change in administrative areas it transpires that the rural areas suffered a persistent decline.

Despite the influence of unemployment in our cities and the lack of facilities for emigration there has been a decline in the number of people on farms in this country in almost every year since 1921. The data covers all the persons on holdings of over one acre in extent except the occupier, his wife and domestic servants. If it is assumed that on the average there are two persons on each holding, generally a man and wife or housekeeper, a very close approximation is obtained to the total persons present on holdings of over one acre.

Again a slight error is introduced by taking two persons as occupiers of each holding, some farms are run by women and employees, but as such cases are few no serious over-estimate is made. Again most of the persons holding between one and five acres of land are not primarily engaged in agriculture; some

market gardeners and poultry keepers, etc., obtain their living by an intensive use or cultivation of a few acres. In general the reduction in the numbers of employees since the war has

TABLE I.

Estimated number of persons engaged in Agriculture.*
England and Wales.

Year.	*Total Excluding Occupiers.*	*Number of Holdings.*	*Estimated Number of Occupiers + wives, etc.*	*Grand Total.*
1921	869,183	420,133	840,266	1,709,449
1923	772,387	411,673	823,346	1,595,733
1924	806,463	409, 383	818,766	1,625,229
1925	803,338	405,708	811,416	1,614,754
1926	794,899	402,639	805,278	1,600,177
1927	774,449	401,734	803,468	1,577,917
1928	772,825	400,895	801,790	1,574,615
1929	770,252	399,247	798,494	1,568,746
1930	741,696	395,823	791,646	1,533,342
1931	716,607	391,941	783,882	1,500,489
1932	697,481	390,469	780,938	1,478,419
1933	715,546	388,433	776,866	1,492,412
1934	687,972	384,272	768,544	1,456,516

* No figures available for 1922.

been accompanied by a change in the systems of farming and those enterprises which required relatively little labour have become more prominent, yet an increase in the area of pasture land at the expense of the arable area need not lead to the engrossing of farms. The majority of farms have been maintained as separate entities although run on more extensive lines. A reduction in the numbers of workers is generally accomplished with less friction than a reduction in the number of farms. The abandonment of a holding may not lead to financial loss in so far as the land is concerned, but the farm buildings under such conditions are generally neglected and fall into disrepair. There is a definite loss of capital to the industry by the abandonment of farms as the expenditure incurred in erection of buildings and in the making of yards, roads, etc., can under such conditions yield but little return.

In every year between 1923 and 1933 there was a decline in the number of holdings. Over the period the number in England and Wales fell by 23,240, or at an average rate of over 2,100 a year. The figure, of course, relates to holdings over one acre. In the early years of the period under review, many small separate fields or holdings near towns and villages were used for building purposes. The decrease in the number of holdings during the

early years may be somewhat abnormal. Two periods of rapid decline are conspicuous, the first being the years 1923 to 1926. After that there followed several years of relative stability; although the numbers were falling, the change was occurring at a rather slower rate. Later, however, particularly in the years 1929 to 1933, a rapid decrease in numbers again set in, and the rate of decline approached that prevailing in the earlier years.

Taking all the persons engaged in agriculture, occupiers, members of their families, and workers, it is found that the period of serious curtailment in the number of holdings, *viz.*, 1929-32, was also one which saw a rather drastic reduction in the total number of persons in agriculture. Migrations of over 30,000 in both 1930 and 1931 followed by over 20,000 in 1932 were the heaviest recorded in any three consecutive years during the period under examination. It is encouraging to find, however, that there was a slight increase in 1933, but as the total number of holdings were fewer in that year by over 2,000 than in 1932, it is probable that there was no increase in the number of occupiers.

It is to be expected that the rural migration will affect people of different ages in different ways. It is rather unlikely that people of advanced years will be anxious to leave the countryside, especially if they have spent the greater part of their lives in rural districts. In fact it becomes more difficult for persons to move as they advance in years or as responsibilities become heavier. Such responsibilities as a family or those associated with the ownership of property create some friction and tend to bind the country dwellers to the region which is known to them and to the work with which they are familiar. A person is less likely to undertake risks when others are dependent upon him and when he has acquired a certain amount of knowledge regarding his occupation, especially when he appreciates the fact that to become skilled in another calling will involve the expenditure of some time and money.

Young people on the other hand are to a certain extent free from the responsibilites and disabilities of the elder folk and in consequence are freer to embark upon the more hazardous task of seeking a position in another occupation and residence in another place. It is not surprising, therefore, to find that migration leads to a partial depletion of the youth of the countryside whereas older folk are not affected to the same extent. The young people therefore who leave for the cities have been reared and educated at the expense of the rural community; they have in fact performed no productive work during the years of country residence, but on the other hand are ready to commence productive work

as soon as they leave. As such a movement is in one direction it is apparent that the country performs a most valuable service to the towns.

TABLE II.

Regular Agricultural Workers (Male).
(England and Wales).

Year.	*Number under 21 years.*	*Number over 21 years.*	*Total.*
1921	155,289	456,783	612,072
1923	138,898	426,925	565,823
1924	140,772	441,491	582,263
1925	137,469	441,944	579,413
1926	135,508	455,904	591,412
1927	134,238	452,835	587,073
1928	129,033	454,151	583,184
1929	125,267	451,706	576,973
1930	118,804	445,708	564,512
1931	116,915	434,983	551,898
1932	115,689	419,649	535,338
1933	113,589	422,519	536,108
1934	107,111	415,472	522,583

By dividing the male regular workers into two groups, those over and under twenty-one years, it is possible to study the effects of the migration upon them. Of course, the number of men under twenty-one years is of necessity far less than the number over that age; in 1923 the number under twenty-one years was equal to 33 per cent. of those over that age, whilst ten years later the comparable figure had fallen to 27 per cent. The depletion of the lower age group was the more severe; in every year except 1924 appreciable numbers left, whereas in five years of the period there were increases in the number of men over twenty-one years. In other words, of every thousand men under twenty-one in agriculture about thirty left annually, whereas in the older group only seven of every thousand left.

Taking both groups together it is found that agriculture suffered a loss of men in eight years of the period; only 1924, 1926 and 1933 showed increases. Between 1926 and 1932 there was a rather unfavourable period, the migration was proceeding at an accelerated pace and during 1931 and 1932 became rather pronounced; and during these two years the exodus of the older men became the more intense, which was contrary to the experience of the other years. During the six years preceding 1932 agriculture lost over 56,000 of its regular male workers and this is equivalent to over 9,000 per annum.

The number of casual labourers is more liable to vary than regular labourers, and it is not surprising to find that the total

fluctuated somewhat during the period. Regular labourers have in general more responsibilities and they look to agriculture for maintenance throughout the year. Greater pressure would therefore be needed to remove this class of people, or on the other hand greater inducement would need to be offered to attract them away from agriculture. Casual labourers habitually move and are more sensitive to the variations in the demand for labour and the wages and opportunities offered in agriculture compared with other industries to which they may turn. To a certain extent, therefore, casual labourers are more sensitive to the fortunes of agriculture, and movement in their numbers may to some extent reflect the prosperity or otherwise of farming in the areas where they are employed.

TABLE III.

Casual Agricultural Workers (Male).
(England and Wales).

Year.	*Number under 21 years.*	*Number over 21 years.*	*Total.*
1921	27,259	103,994	131,253
1923	24,990	79,099	104,089
1924	26.461	88,533	114,994
1925	23,878	90,870	114,748
1926	19,733	79.198	98,931
1927	18,034	67,078	85,112
1928	11.418	75,535	86,953
1929	11,278	79,619	90,897
1930	10.453	69,788	80.241
1931	9,347	62,255	71,602
1932	9,317	64,698	74,015
1933	10,924	78,531	89,455
1934	9,245	72,425	81,670

A floating labour force of this kind is dependent to a large extent upon certain systems of farming, especially those which call for a heavy complement at certain busy seasons of the year. In general such systems are not widespread, as the majority of farms in England and Wales do not require to engage supplementary labour for certain seasons of the year. Additional labour from a village may be employed for a few days during harvests, but people so employed do not come into the category of farm labourers; they are engaged in other work and only render intermittent help to farmers. It is apparent, therefore, that the numbers of casual labourers engaged may be dependent upon the prosperity of certain systems of farming as *e.g.*, sugar beet, potato or hop production, and a period of prosperity or adversity in these branches of farming may affect the numbers

of casual labourers quite irrespective of the conditions of agriculture generally.

The total male casual workers in England and Wales stood at about 131,000 in 1921, but by 1923 it was 27,000 less; in the two following years there was a slight recovery, but the 1921 figure was not reached in any subsequent year. The number touched its lowest point in 1931, when it stood at only 71,000, over 59,000 fewer than in 1921. The heavy migration of this class of labour out of agriculture during the decade may be gauged from the fact that for every hundred men employed in 1921 only fifty-four were left in 1931.

Movements of casual workers from year to year have been far more erratic than those of regular workers, in the case of both the younger and older men. The losses of those under twenty-one were positively prodigious between 1921 and 1932; in the former year over 27,000 were engaged, whilst in the latter it had fallen to 9,000—a 66 per cent. decline. With the exception of 1924 and 1933 losses were experienced in every year.

In the case of the men over twenty-one years, losses were only suffered in six years. Nevertheless the total in 1931, the lowest year on record, was only 60 per cent. of that recorded in 1921. On the other hand it is encouraging to find that the 1933 figure was only slightly less than that of 1923.. In general it may be said that during this decade casual male labour of over twenty-one years has not seriously declined, although in certain years it fell rather low. It must be reiterated, however, that casual labour is mainly employed by farmers adopting certain systems of farming, and that the conditions obtaining in such regions may not reflect the general agricultural situation. Yet the young men of this class have been seriously depleted, a fact which indicates that as time passes fewer will be available from which to fill the ranks of the older men.

The causes of rural migration exert their influences in different ways in the many regions where migration occurs. Some observers maintain that rural folk are so attracted towards the towns that when compared with the country the urge to migrate becomes irresistible. There are, it is true, many factors in the cities which appeal to young folk, such as theatres, cinemas, sports, the contacts with other folk and all the activities associated with aggregations of people. To some it appears as a place of opportunity, where enterprise would find a better reward, whilst others realise that distinction is more often connected with the cities. A few may regard it as a place where monotony and physical drudgery can be avoided. It may be true that such

psychological causes may account for the movement of some classes of people, but it is probable that there are others of an economic character which play a more important part.

On the other hand some claim that migration is occasioned very largely by the low incomes obtainable in agriculture compared with some other callings. Wages of farm labourers have in general been lower than those in other occupations to which the men could turn in periods when there was a steady demand for people from the land. In mines and factories migrants from the country have had no great difficulty in finding employment, especially in situations which did not require much preliminary training. Young men off the farms were often easier to control, they had not previously been conversant with the activities of trade unions, and in consequence were more amenable to supervision. Even during the years when there has been an ample supply of labour available to meet the requirements of all industries, there was still a demand for labourers drawn from the country, the rise of a large body of unemployed labour in the towns did not create so much of a handicap for the rural migrant as would at first appear.

In pre-war years wages of farm labourers were extremely low, even when allowance is made for the perquisites supplied, and during the decades when industries in this country were enjoying prosperity there was a marked disparity between the cash wages in town and country. It cannot be denied therefore, that the incentive of higher wages and possibly shorter hours acted as a potent force. But it is not the cash wage that is ultimately of importance to an employee. the amount of commodities which can be bought for the money must be considered. During a period of falling prices, real wages may rise as the movement of cash wages lags behind. During the eighties and nineties of last century prices of food were falling rapidly as cheap supplies were arriving from abroad. The real wages of the farm worker, on the other hand, were rising, yet during this period migration was proceeding rapidly. In the decade that followed, *viz.*, 1901-11, there was a rise in the price of foodstuffs, real wages were falling, yet during this period the agricultural population increased rather than decreased.

Generalisation regarding the factors responsible for the exodus of people from the country suffers from one conspicuous weakness in that the same forces are suggested as causes of the male and female migrations. There is no doubt that some of the disadvantages associated with the country, especially those of a social rather than of a purely economic nature, exert a greater

influence upon the minds of the women folk. Perhaps one of the most serious weaknesses prevailing in some of the rural districts has been the lack of suitable houses. This is particularly serious amongst the farm labouring class; big families are often found in small cottages, and as the children grow up the absence of adequate facilities and the impossibility of observing even the most necessary codes of decency often lead to an intolerable situation, the home becomes repugnant to youth under those conditions, and it is not surprising that migration occurs.

Very little capital has been invested in rural houses during the last fifty years, especially in the provision of labourer's cottages. During this time, therefore, the supply of houses has tended to diminish as the old houses fell into disrepair and later into ruins. Most of the older types of cottages were erected when the laws governing houses were more lax than they are at present. They were built very easily and quickly, the walls often a mixture of stones, wood and earth, and a roof of thatch sufficed. During the last three or four decades such houses have been disappearing rapidly, but no serious attempt has been made to provide alternative accommodation. Of course, it is not suggested that the relationship between the movement out of agriculture and the lack of suitable houses is simple; the migration itself has in some areas led to the abandonment of many houses which were in a tolerable state. Nevertheless, when children attain maturity they realise the disadvantages of living in houses which have only received the minimum of repair, and have not been modernised at all. It is true that under the " grid " electricity is slowly penetrating into rural areas, but even yet it is only the more prosperous people that enjoy its use. Very few cottages have been connected as at present, the charges for installation and the cost of current are beyond the means of people who only enjoy incomes approximating to the farm labourer's wage. The absence of such conveniences as gas and water under pressure also places the farm houses and cottages at a disadvantage in the eyes of women when compared with conditions in a town.

On the other hand, young women experience no great difficulty in finding employment in towns as domestics. There is always a keen demand for this class of employee, as in general they are more easily handled than the city born girl. Further the latter generally attempt to obtain a situation superior to a domestic, and in consequence there is always a number of situations for maidservants available in the cities.

In the case of England and Wales there has been a marked drop in the number of regular female workers during the last

decade. A most rapid decline occurred immediately after the war, but this was to be expected, as large numbers of women were employed in agriculture during the war, and in subsequent years a fall in the number of female employees was inevitable. But even after a return to normal conditions some years later the migration of women continued, and in the case of regular workers was rather severe duing the last two years of the period. It is true, however, that the number of regular women workers has fluctuated somewhat; between 1923 and 1928 there was an increase, but in the earlier year a very low figure was reached. After 1928, however, each year has shown a decline on the one before, and the total in 1933 was much below the average for the years under review.

TABLE IV.

Female Agricultural Workers (Regular and Casual).
(England and Wales).

Year.	*Regular Workers.*	*Casual Workers.*	*Total Workers.*
1921	73,180	52,678	125,858
1923	59,477	42,998	102,475
1924	62,276	46,930	109,206
1925	59.940	49,237	109,177
1926	62,949	41,607	104,556
1927	62,629	39,635	102,264
1928	67,418	35,270	102,688
1929	67,004	35,378	102,382
1930	65,337	31,606	96,943
1931	64,409	28,698	93,107
1932	62,314	25,814	88,128
1933	59,603	30,380	89,983
1934	58,225	30,494	88,719

The number of casual women workers, in contrast with the case of the men, approaches quite closely to the number regularly employed. The total women engaged in agriculture however, is not large; in 1933 only about twenty women and girls were employed for every hundred men. Casual female workers declined rapidly between 1921 and 1925, but afterwards the number remained fairly steady for a few years; later the number fell away rather rapidly until in 1932 only 49 per cent. of the 1921 figure remained. Taking both classes of female workers together, and excluding the years immediately following the war, it is found that between 1928 and 1932 was a rather unfavourable period as the decline was persistent throughout, but in 1933 there was a slight recovery. Over the period under review, however, agriculture has lost about one third of its

female workers, casual employees showing the more severe decline.

The conditions governing the movements of people in Wales may in some respects be peculiar, as the country is very largely one of peasant occupiers, and in consequence the proportion of agricultural labourers to farmers is relatively small. In England the greater part of the farm work is done by hired employees, whereas in Wales it is performed by members of the occupier's family. The class of "regular workers" in Wales therefore, would very largely consist of the sons and daughters of the farmers, whereas in England the majority falling into this category would be wage earners.

It is probable that the response made by the two classes of people to the forces influencing migration would be different. The rate of agricultural wages paid is likely to play a more important part in the problem where a large body of labourers exist, as they have probably less direct interest in agriculture than the members of farm families. The latter would have stronger ties with the soil as a large proportion of them would themselves aspire to become farmers. The period of waiting. *i.e.*, from the time they leave school until they embark upon an independent business career, may be a very long one, and during that time but few obtain an income as high as the wage of an agricultural labourer of the same age. Nevertheless most members of a farm family hope that they will eventually receive as full a reward for their services as the financial situation of the family will allow. Sometimes this hope is fulfilled and in the long run no financial loss is suffered. It is often found that on family farms longer hours are worked and smaller cash incomes are enjoyed by many folk than would be the case were they employees on other farms. Yet in most cases it is realised that capital is accumulating on their behalf and that to leave for the city or even to leave the farm will, in general, lead to the loss of that capital.

This kind of tie, which is somewhat peculiar, is quite common in Wales and serves to keep many persons on the land, although the reward they receive for their services is much less than that which they could earn in other ways. It is not to be denied, of course, that many farmers' children would rather work with the family even longer hours and for a lower income than become employees in another industry. The so-called "independence" which they enjoy on their own farms is valued very highly, whilst it is probably true that young people acquire better knowledge

of farming methods and particularly of farming business than if they were engaged as employees on other farms.

The really ambitious and enterprising folk who leave the Welsh countryside often attain positions where the financial return is somewhat higher than in the callings which they leave. The development of education during the last fifty years has, in many, aroused ambitions that would otherwise remain latent. The nature of the education provided in both elementary and secondary schools may have had no small effect; until recently the subjects taught and the methods of teaching them too frequently fostered a distaste for agriculture. There has undoubtedly been too much of an urban bias in rural education, with the result that city situations are viewed in a somewhat favourable light, whereas agricultural callings have been placed at a discount. The bias of parents and friends against rural living, and the association of personal ambition with a non-agricultural occupation are, however, of greater importance.

In recent years the growth of transport facilities has made an enormous difference to the country dweller. In the first place it has acted as a widening channel through which people can pass with greater ease than formerly to and from the towns. When ample facilities exist to effect a flow with the minimum of friction, it is to be expected that the introduction of any new forces, tending to disturb the situations as *e.g.*, changes in our fiscal policy, would ultimately cause a new equilibrium to be established.

Again the spreading of the daily newspaper in rural areas and later the radio serve to keep the country folk in closer touch with developments in cities than was the case at one time. To migrate therefore, from the country is not necessarily a step in the dark, as it is now possible to gain fairly close information regarding town conditions. A movement towards the cities is justified if the conditions in both are such that the persons who go enjoy a higher standard of living and a fuller life in consequence. Development in the science of food production in this and in other countries has had a very pronounced effect upon the farming population of the commercial countries of the world. The aid which machinery and mechanical power are rendering the farming community have made each man, on the average, far more productive than was previously the case. Each man engaged in the production of food is now turning out an increasing quantity per annum, and this is occurring at a very rapid rate in some overseas countries from which we obtain supplies. On the other hand the consumption of food does not keep pace

with rising production, and prices tend to fall to low levels. With the scientific developments in production, it must be realised that an ever lessening proportion of the total population is needed to provide the food requirements of the community.

Welsh agriculture has not been immune from the effects of expansion in oversea countries; the prices of its products have been influenced to a marked degree by the prices of imported commodities. In the years preceding 1924, the coal industry of South Wales was, in general, enjoying relative prosperity, and large numbers migrated from the agricultural counties to the mining areas, as there was always a demand for labourers in the industrial regions. During the last decade, however, while there has been a surplus of men available, yet many young men from rural areas have been able to find empoyment, although the demand has been on a considerably reduced scale.

The reduction in the number of regular workers in Wales since 1921 has not been as severe as for the country as a whole. There was a rather sharp drop immediately after the War, but subsequently numbers remained fairly steady. The numbers of younger men again show the most serious decline; over the period those under twenty-one fell by 13 per cent., whereas those over that age were only lower by 3 per cent. Casual workers have shown a very serious decrease; they fell by nearly 25 per cent. between 1921 and 1923, and in several of the years that followed there were rather severe reductions. Agriculture in Wales became almost depleted of casual workers under twenty-one; of every hundred employed in 1921 only thirty-six remained in 1933, although a greater proportion of the older men remained; nevertheless there was a fall of 48 per cent. during the decade. Almost every year saw considerable numbers leaving, until in 1933 less than half the 1921 total remained.

The numbers of female regular workers engaged in farm work in Wales is comparatively large; for England and Wales together females only amount to 11 per cent. of the males; in Wales, however, the figure is nearly 30 per cent. Again, in contradistinction, the number on farms has not shown any definite decline since 1921. There have been changes in most years, but in 1932 the total was actually higher than it was eleven years earlier. In the case of casual female workers, numbers remained fairly stationary until 1927, but subsequently fell off appreciably. The decline, therefore, of 15 per cent. in total females between 1921 and 1933 is partly accounted for by the fall in the number of casual workers, but it is principally due to the big drop in the regular workers during the last year of the period.

Taking all classes of workers into consideration, it is found that there is a close similarity between the Welsh figures and those for the whole country. Between 1921 and 1933 all agricultural workers in England and Wales declined in numbers by 18 per cent.—the corresponding figure for Wales is 17 per cent. It is probable, however, that the financial or economic aspects of the problem have less effect in Wales owing to the important difference in the constitution and nature of the labour supply.

THE FINANCIAL RESULTS OF DIFFERENT TYPES OF FARMS IN WALES.

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The groups of farms of which the accounts are herewith presented have been chosen with a view to describing the economic situation of some of the main farming types in Wales. It is, however, only possible to draw attention to the broader differences which exist between the general form, economic structure, agricultural characteristics, and financial results of four farming types, and it is necessary to ignore many of the important differences found to exist within each of the broadly described types. No one dealing with a set of accounts of this character would on due consideration be prepared to assert that they provide a fully representative sample of all the farms in Wales in the sense that if all the farms were recorded the results would be exactly as those of the sample group. But at the same time it may be said that in total this group is generally representative of farms in Wales and that in a very near degree. The evidence available indicates possibilities of only very slight divergence of this group from the results of the whole if these were ascertainable.[1] The same degree of representativeness cannot be claimed when classification is made on the basis of farm-types because the same opportunities are not available of measuring the divergence of cropping, stocking, etc., of any of the type groups with a similar type group for the whole of the Principality. The results for the farm-types do, however, show comparatively how different groups of farmers have fared. If the financial results as shown by the type-groups are inadequate as a measure of the position of the

[1] Economic Depression in Welsh Farming. Howell, J. Pryse. This *Journal*, Vol. XI, 1935.

industry they are at least useful in showing which way the winds of fortune have been blowing. It can further be stated that the accounts dealt with cover a fairly "normal" group of farms, and except to a slight extent in the "Mixed Farm" group they do not include any holdings of highly specialised or intensive production such as poultry farming or market gardening. They cover a group of farms such as might be found in almost any county in Wales (although they are in fact obtained from eight of the counties) in which occupiers of land are using their farms for general or customary purposes and operating them at about the normal standards of their areas.

The number of records available each year has varied with the supply from farmers. Those used are those which have satisfied the Department as to their accuracy in detail, and no other selection has been made. These records have been classified by types of farms as follows :—

Cattle and Sheep (Poor Land).
Cattle and Sheep (Better Land).
Mixed Farms.
Cattle and Milk.

The classification of the type-groups is done on the basis of knowledge of the farms, together with examination of the sources of receipts. The chief sales of all these type-groups are of livestock and livestock products, but the proportions of sales of sheep, cattle, dairy produce, milk, etc., vary in the different farm-types. Generally, Wales is a pastoral country. Its useable and used land stretches from the sea-level to altitudes of 2,000 feet and over. There are a few areas in the south-west and north-east in which crops are grown for sale, but most of the crops are grown for use on the farms. Much even of the crops sold is not for final consumption off farms, but is ultimately of the character of inter-farm exchanges, even though these are made through merchants. The chief crop grown for final consumption off farms would be potatoes, and even these sales are small, for Wales is an importing country as regards this crop.

Size of Farms.

The average size of the farms for the different years in each group and their average rent per farm and per acre is given in Table I. These figures are discussed for each group in turn.

Cattle and Sheep Farms (Poor Land). The characteristic feature of this type is poor land and low rentals, but with size of holding showing wide variations. The range in acreage has remained the same in the first three years (68 to 489 acres) and

for the same period one-half of the farms lie between 100 and 400 acres. In the last two years the range of size is from 68 to 990 acres, and in 1932-3 eleven out of the seventeen farms, but in 1933-4 ten out of the sixteen farms lie between 100 and 400 acres. In each of the five years there were two farms under 100 acres.

The range of rent remains fairly constant in each year and over the whole period varies from 2s. 4d. per acre to 12s. 8d. per acre. The proportion of farms having rentals of less than 8s. per acre is small, and only in the last two years do they represent

TABLE I.

Average Size of Farms and Average Rent per Farm and per Acre in Type Groups from 1929 to 1934.

Year.	*No. of Farms.*	*Average Size.*	*Rent per Farm.*	*Rent per Acre.*
		CATTLE AND SHEEP : (POOR LAND.)		
	No.	*Acres.*	£ s. d.	s. d.
1929–30	15	234	76 7 7	6 6
1930–1	15	246	94 11 4	7 8
1931–2	16	260	104 13 10	8 1
1932–3	17	299	86 3 10	5 9
1933–4	16	304	80 17 7	4 4
Average (5 years)		270	88 11 9	6 7
		CATTLE AND SHEEP (BETTER LAND).		
1929–30	6	131	125 13 1	19 2
1930–1	17	117	98 7 10	17 11
1931–2	16	119	112 7 7	18 11
1932–3	15	109	95 9 7	17 6
1933–4	12	116	96 0 11	16 7
Average (5 years)		115	103 6 1	17 11
		MIXED FARMS.		
1929–30	10	79	86 19 4	22 1
1930–1	9	81	126 17 0	31 3
1931–2	14	78	119 14 8	30 10
1932–3	12	84	131 10 10	31 4
1933–4	11	78	101 17 3	26 3
Average (5 years)		80	114 0 11	28 6
		CATTLE AND MILK.		
1929–30	11	85	116 3 11	27 5
1930–1	10	114	106 19 6	18 9
1931–2	18	119	134 4 10	22 7
1932–3	24	107	144 11 4	26 11
1933–4	23	125	158 2 11	25 4
Average (5 years)		112	138 0 9	24 7

one-fourth of the total. With the exception of 1931-2 and 1932-3, when eight out of sixteen and six out of seventeen farms have rents of over 9s. per acre, something like half of the farms in other years have rentals of between 8s. and 9s. per acre. For the whole period from 1929 to 1934 the average size is 270 acres and the rent 6s. 7d. per acre.

Cattle and Sheep Farms (Better Land). This type is represented by a smaller type of holding on better land which allows more intensive stocking. While the average size over the five years is 115 acres, the range is from 47 to 420 acres, but over one-half of the farms in each year lie between 50 and 150 acres. Only a small proportion of the farms in any year are below fifty acres. The rents range from 8s. 8d. to 30s. per acre and about one-half of the farms in each year have rentals of between 15s. and 20s. per acre. The average rent for the five years is 17s. 11d. per acre.

Mixed Farms. As regards size the mixed farms group shows a smaller range of variation between individual cases from 30 to 190 acres, and the majority of the farms in each year fall below 100 acres. For the whole period there are only four farms that exceed 150 acres. But this group shows a very wide range of rentals—from 9s. 4d. to 60s. 10d. per acre. Rentals on the whole are higher in the second, third and fourth year, and lowest in the first year. Over the five year period, the average rental per acre is 28s. 6d. and the average size per farm is 80 acres. In average size the farms have not varied much from year to year.

Cattle and Milk Farms. In this group, the size of the farm ranged during the period from 1929 to 1934 from 18 acres to 300 acres, but half of the farms in each year lie between 50 and 150 acres. There are only three farms of over 250 acres, and these occur in the second, third and fifth year respectively. The percentage of farms having acreages of between 150 and 250 acres show a decided increase in number in the last three years. The variation in the average size for the group in each year is from 80 acres to 125 acres, with a general average of 112 acres over the whole period. Rents range from 9s. 7d. to 66s. 2d. per acre, and the majority of the rentals in each year are above 20s. per acre. There were fewer farms with rentals of between 15s. and 20s. per acre than of those having rentals of under 15s. per acre. Over the five years the average rental for this group was 24s. 7d. per acre.

Crops.

Cattle and Sheep (Poor Land). As might be expected the growing of crops is not an important feature of the farming practice on this group. The condition of the soil, the elevation

and the exposed situation of these farms is not conducive to much arable cultivation. Over the five year period the area under crops does not attain 6 per cent. of the total area : in no year does it reach 8 per cent., and in the year 1933-4 there was only slightly over 4 per cent. under crops. One noticeable feature of this group of farms is a gradual decline in crop acreage accompanied by a large proportion of the land under rough grazing as the farms increase in size. Of cereals, oats is of major importance, and on a five years average constituted nearly 58 per cent. of the arable crops. Barley comes second with nearly 16 per cent., then wheat with 8½ and mixed corn with 2½ per cent. of

TABLE II.

Average use of Farm Land in Type Groups 1929-34. (Percentage of Total Farm Area in each case).

CATTLE AND SHEEP FARMS (POOR LAND).

Year.	*No. of Farms.*	*Average Size.*	*Average Composition of Farm Acreage.*							
			Crops.		*Hay.*		*Pasture.*		*Rough Grazing.*	
		Acres.	*Acres.*	%	*Acres.*	%	*Acres.*	%	*Acres.*	%
1929–30	15	234	17	7.5	25	10.7	76	32.2	116	49.6
1930–1	15	246	18	7.3	25	10.0	86	35.0	117	47.7
1931–2	16	260	16	6.0	26	10.0	99	38.0	119	46.0
1932–3	17	299	14	4.7	23	7.8	69	23.1	193	64.4
1933–4	16	304	13	4.2	23	7.7	68	22.3	200	65.8
Average (5 years)		270	16	5.8	24	9.0	79	29.4	151	55.8

CATTLE AND SHEEP FARMS (BETTER LAND).

1929–30	6	131	29	22.1	26	19.6	60	45.6	16	12.7
1930–1	17	117	14	12.0	24	20.7	79	67.3	0	0.0
1931–2	16	119	16	13.8	26	21.4	75	63.2	2	1.6
1932–3	15	109	17	15.9	24	22.1	58	52.9	10	9.1
1933–4	12	116	14	12.2	24	20.3	66	56.8	12	10.7
Average (5 years)		115	17	14.4	24	21.0	68	59.0	6	5.6

MIXED FARMS.

1929–30	10	79	19	24.8	17	21.9	43	53.3	0	0.0
1930–1	9	81	14	16.9	24	29.9	43	53.2	0	0.0
1931–2	14	78	15	18.9	21	27.1	40	51.0	2	3.0
1932–3	12	84	12	14.6	22	26.3	48	56.2	2	2.9
1933–4	11	78	14	18.1	19	25.1	41	52.4	4	4.4
Average (5 years)		80	15	18.5	21	26.0	42	53.2	2	2.3

CATTLE AND MILK FARMS.

1929–30	11	85	10	11.6	22	26.1	51	60.4	2	1.9
1930–1	10	114	12	10.7	22	19.6	61	53.5	19	16.2
1931–2	18	119	13	10.7	30	25.2	62	52.6	14	11.5
1932–3	24	107	12	11.6	28	25.9	60	56.0	7	6.5
1933–4	23	125	12	9.3	35	27.7	70	55.9	8	7.1
Average (5 years)		112	12	10.6	29	25.5	62	55.4	9	8.5

the total crops. There was an increase in the percentage of arable land under oats during the period from 1932 to 1934 and this has been obtained at the expense of barley, but taking the proportion of arable land under cereals an increase is noticeable from 1929-30 onwards and a decline in the percentage of land under potatoes and green crop. Potatoes occupy on an average slightly over 6 per cent. of the tillage area and turnips and swedes and rape 7.2 and 5.3 per cent. respectively. Mangolds are the least important of the root crops and only averaged 1.8 per cent. of the arable area.

The proportion of land reserved for hay varies from 7.7 to 10.7 per cent. of the total area of these farms, with a general average of 9 per cent. over the five year period. Pasture on an average represents slightly over 29 per cent. with a variation of from 22.8 to 38 per cent., while rough grazing on a five year basis averaged over 60 per cent. and varied from 46.0 to 65.8 per cent.

Cattle and Sheep Farms (Better Land). On this group about 14½ per cent. of the land is under crops, 21 per cent. under hay, 59 per cent. under pasture and about 5½ per cent. under rough grazing. Except in the first year (1929-30) when it represented 22 per cent. of the total area, the percentage of tillage land from year to year did not show very great variation. The area under hay remained fairly constant and the greatest variation between one year and another was only 2.5 per cent. The percentage of land under pasture is influenced to some extent by the proportion of land under rough grazing and a decrease in the area under permanent grass in any particular year is usually associated with an increase in the area under rough grazing. Cereals dominate the arable crops and on an average account for nearly 76 per cent. of the tillage land, and of this oats represents 39.9 per cent., wheat 14.3 per cent., barley 14.6 per cent. and mixed corn 7.1 per cent. Wheat has gained in importance from 1931-2 onwards and there appears to have been a decline in area of barley and mixed corn, for the same years. Potatoes are not extensively grown and for the five year period only average 3.9 per cent. of land under crops. In comparison with the *Cattle and Sheep Farms (Poor Land)*, the percentage of turnips and swedes grown to the total tillage land is about the same—namely 7 per cent., but there is a higher proportion of mangolds grown (3.4 per cent. as against 1.8 per cent.). Rape on the other hand is of minor importance and only represented on an average 2.4 per cent. of the arable land as against 5.3 per cent. for the *Cattle and Sheep Farms (Poor Land).*

Mixed Farms. Of all the groups, this has the highest percentage of tillage land and this is reflected in the receipts from crops which exceed those for any of the other groups. On a five year basis, an average of 18½ per cent. of the total area is under crops, but the tillage land within this period shows a variation of from 14.6 to 24.8 per cent. In general, any reduction in the area under crops is usually accompanied by an increase in the area under hay. On an average hay occupied 26 per cent. of the area and pasture slightly over 53 per cent. and the area under permanent grass remains fairly constant from year to year. Rough grazings form but a very small proportion (2.3 per cent.) of the land and this small area only occurred during the last three years.

While oats still remains the dominant cereal crop, there is certainly more prominence given to the growing of barley and mixed corn on these farms than on the other farm groups. On an average the proportion of oats to total crops is 33.2 per cent., barley 20.5 per cent., and mixed corn 15.4 per cent. Of roots, potatoes occupy on an average 7.6 per cent. of the tillage land, turnips and swedes 5.9 per cent., mangolds 4.6 per cent., and rape 2.3 per cent. Compared with the two previous groups, more importance is attached to the growing of mangolds and less to turnips and swedes. During the years from 1929 to 1932 some sugar beet was grown, but the area under the crop was very small.

Cattle and Milk Farms. As dairying on these farms is usually associated with grassland, it is to be expected that the area under tillage would not be very high. On an average the crop area only represented 10.6 per cent. of the total land. The variation between one year and another did not exceed much over 2 per cent. About one fourth of the land is under hay, and this varied in the different years from 19.6 to 27.7 per cent. Slightly over threequarters of the land is under permanent grass, and on an average there is 8.5 per cent. under rough grazings.

On an average cereals account for 63.3 per cent. of the land under crops, with oats at 44.2 per cent. and wheat, barley and mixed corn together making a total of 19.1 per cent., and with about the same percentage under each crop. During the last three years the proportion under wheat has increased, and there has been a tendency for oats and barley to decline. Potatoes averaged 8.7 per cent. of the tillage land, and on the whole more prominence was given to this crop in the last three years. Turnips and swedes averaged nearly 10 per cent. and mangolds 4.6 per cent., while rape was of minor importance and only accounted for 1.5 per cent. of the area under crops. Other crops

which consisted mainly of kale averaged 8.8 per cent., and in the first two years a very small percentage of the tillage land was devoted to sugar beet.

Livestock Carried.

Cattle and Sheep Farms (Poor Land). With high proportons of rough grazings, and only small areas under crops, the ratio of horses to land is low at approximately one " work " horse per 100 acres. With poor demand for horses and ponies during the greater part of the period, there was no stimulus to breeding and the number of " other " horses was also small. Cattle are of less importance than sheep, yet they make important contributions to sales. The proportion of dairy cows to " other " cattle remains fairly constant from year to year, and there is practically no change in the system of herd management. The range is from eight to ten cows and from about eighteen to twenty-four " other " cattle. Butter making is combined with the rearing of calves, and herds are maintained mainly by home rearing. Some purchases of cattle are made but these in the main consist of additional calves for rearing purposes. Practically all the cattle are sold as stores, and the proportion of fattening done is very small indeed.

TABLE III.

Average Number of Livestock per Farm and per 100 Acres in Type Groups. (5 years average from 1929 to 1934).

Type Group.	*Cattle & Sheep Farms. (Poor Land.)*		*Cattle & Sheep Farms. (Better Land.)*		*Mixed Farms.*		*Cattle & Milk Farms.*	
Average Size (Per Farm).	Acres 270		Acres 115		Acres 80		Acres 112	
	Per Farm. No.	*Per 100 Acres. No.*	*Per Farm. No.*	*Per 100 Acres. No.*	*Per Farm. No.*	*Per 100 Acres. No.*	*Per Farm. No.*	*Per 100 Acres. No.*
Work Horses	2.7	1.0	2.6	2.3	2.9	3.6	2.9	2.5
Other Horses	2.4	0.9	1.4	1.2	0.6	0.8	1.2	1.1
Total Horses	5.1	1.9	4.0	3.5	3.5	4.4	4.1	3.6
Dairy Cows	8.8	3.2	7.5	6.5	8.1	10.2	17.1	15.2
Other Cattle	20.8	7.7	21.5	18.7	20.2	25.3	16.8	14.9
Total Cattle	29.6	10.9	29.0	25.2	28.3	35.5	33.9	30.1
Breeding Ewes	134.1	49.8	67.0	58.1	22.8	28.6	41.0	36.5
Other Sheep	100.4	37.2	51.0	44.3	21.7	27.2	30.6	27.2
Total Sheep	234.5	87.0	118.0	102.4	44.5	55.8	71.6	63.7
Breeding Sows	1.7	0.6	1.4	1.2	1.7	2.2	1.7	1.5
Other Pigs	6.5	2.4	6.1	5.3	18.8	23.6	10.4	9.3
Total Pigs	8.2	3.0	7.5	6.5	20.5	25.8	12.1	10.8
Laying Flock	62.2	23.1	71.4	62.0	116.0	145.5	75.9	67.6
Other Poultry	29.7	11.0	53.0	46.0	77.3	96.9	50.9	45.3
Total Poultry	91.9	34.1	124.4	108.0	193.3	242.4	126.8	112.9

The management of the flocks has continued very much the same over the whole period. The sheep are of the Welsh Mountain type with, in some cases, a few crossbreds. Permanent flocks are kept, and on some farms it is the custom to buy in some sheep each year. These usually consist of store lambs for fattening purposes. While some fattening was done, sales consist in the main of store ewes and lambs.

On some farms there were no breeding sows kept. Here the policy was to fatten one or two pigs for household consumption and sometimes in addition to buy in a few weaners to be ultimately sold as porkers or baconers. Where breeding was carried on the number kept varied from one to four breeding sows. The tendency was to sell the progeny as weaners but some porkers and baconers were sold.

As might be expected on farms at fairly high altitudes poultry are not an important feature of the farming practice. There is, however, a decided tendency towards an increase in the number carried.

Cattle and Sheep (Better Land). While the number of horses kept per farm has remained fairly constant during the whole period there is a slight decline in the horse population during the period from 1932 to 1934, and the same tendency is seen in both the " work " and " other " horses. The average number of " work " and " other " horses over the five years was 2.6 and 1.6 per farm respectively.

The average number of cows is 7.5 and other cattle 21.5 per farm, and very little variation occurs in the average number carried in each year. The ratio of cows to " other " cattle has also kept fairly constant over the whole period, and averages about three " other " cattle to one dairy cow. Butter-making is combined with the rearing of calves. Purchases consist mainly of calves and store animals of twelve to eighteen months old. These are bought in the spring for summer grazing or in the autumn for growing forward. Occasional purchases of breeding animals are made. The majority of the cattle sold go off as stores, the remainder being draft cows or heifers sold as breeding stock and occasionally also a few beasts in fat condition.

The average size of the breeding flock of ewes is sixty-seven and fifty-one " other " sheep per farm. While the proportion of breeding ewes to " other " sheep remains somewhat similar in each year, the total number of the flock has varied from 98 to 181 sheep per farm over the five year period. On the majority of the farms a permanent flock of ewes is kept; others buy in a fresh ewe flock each autumn. The progeny of the flock

are mainly sold as lambs, the remainder, together with some store sheep bought in, are kept on for feeding on the aftermath and root crop and disposed of in the late autumn or early spring.

Over the five year period the average number of sows kept was 1.4 and " other " pigs 6.1 per farm. From 1930-1 to 1933-4 the pig population showed a tendency to decline both as regards breeding sows and other pigs. Where sows were kept the progeny was sold either as weaners, porkers or baconers. Where no breeding was done the system was to buy in weaners or forward stores to be ultimately disposed of for the pork or bacon trade.

The poultry flocks in this group average about 124 head, of which 71 are laying flock. The number carried show a tendency to increase from 1929-30 to 1933-4.

Mixed Farms. The group carries more working horses per 100 acres than any other type, but does less breeding and rearing.

Breeding cattle number, on the average, about eight cows per farm and " other " cattle about twenty per farm. Again in this group cows are mainly kept for the rearing of calves and the production of butter. Purchases consist of calves and store cattle. The major part of the cattle are sold as stores, but a fair proportion are fattened off. Other sales are draft cows and down calving heifers.

Sheep are not of great importance in this group. Some of the farms maintain a small breeding flock. Others rely entirely on purchases. The sheep bought are ewes for the rearing of fat lambs or store lambs for fattening on the summer pastures or for feeding on roots and some concentrates and prepared for sale in the late autumn or early part of the year.

Pigs assume greater prominence on this group than on any of the other type groups. On a five year basis the average number of pigs carried is 1.7 breeding sows and 18.8 " other " pigs per farm. A large number of weaners or forward stores are bought and these are ultimately sold as porkers or baconers.

Poultry again are of much greater prominence in this group than on the other type groups, and there is a definite increase in the number carried per farm, from 1929-30 to 1933-4. Over a five year period, the average head of poultry was 193 per farm, of which 116 were laying birds.

Cattle and Milk. The outstanding feature in this group is the high number of dairy cows. The cow population per farm has remained fairly constant in each year, and this is equally true of the " other " cattle. On a five year basis the average head of cattle was about thirty-four per farm, of which about

seventeen were dairy cows. In general, the group average per farm in each year and over the whole period shows that the proportion of dairy cows to "other" cattle has remained fairly constant and that the herd is made up of 50 per cent. dairy cows and 50 per cent. "other" cattle. The dairy herds are maintained in some cases by the introduction of home bred heifers, in others some cows are replaced annually by purchase. A few stores are also bought. These are disposed of as forward stores or fattened off for the butcher.

Sheep do not occupy a very important position on this group. Small breeding flocks or flying flocks of ewes are maintained for the production of fat lambs. In other cases store lambs are bought for clearing up the pastures after the dairy cows. On a five year basis the head of sheep averaged about seventy-two per farm, of which forty-one were breeding ewes.

Pigs are relatively unimportant. Breeding is pursued on some farms. Others rely entirely on purchases of weaners or forward stores, while on others a combination of the two methods is carried on. Sales consist of weaners, porkers or baconers. Over the whole period the total head averaged about twelve pigs per farm. Of these about two were breeding sows.

For the group as a whole poultry flocks are relatively small, and from 1930-1 there was a definite increase in the size of flocks. The number carried per farm over the five years average about 127, of which 76 were laying birds.

Manual Labour.

Accurate recording of labour used on family farms is not a simple or easy matter. The labour that resides on the farm is not necessarily used on the land and the livestock. In some cases there is more resident labour than can possibly be fully utilised on the crops and stock known to be present and yet no other occupation is regularly followed. In other cases especially of only a man and his wife, or only a man, wife and another relative, it is known that the labour force required on land and stock cannot be provided without considerable contribution by the wife. The principle adopted in all cases has been that of attributing to farm work only the amount actually used. The calculations are made with care after visits to the farms, examination of records and generally with full consideration of all the ascertainable facts. The final figure may include full-time for all active members of the family, it will exclude the wife if she does not contribute to productive work; or it will exclude part of the time of any other member of the family who does not contribute

his or her full time to this work. The same conditions arise in respect of employed labour, but in this case on the basis of recorded time and payment. No charges for manual labour of the farmer (or occupier) and his wife are included in expenses. Labour of relatives (mainly sons and daughters) is charged in expenses, at prevailing rates of wages for employees, on the basis of time worked.

The manual labour on a five year basis is set out in Table IV.

On the Cattle and Sheep (Poor Land and Better Land) groups the family labour exceeds that of the hired labour when the work of the farmer and his wife is taken into consideration. On the same basis the labour contribution of hired workers exceeds that of family labour only on two of the type groups—namely the Mixed Farms and the Cattle and Milk Farms. The variation in the average number of persons employed per farm in the different type-groups is not very great. The total persons engaged (including the manual work of the farmer and (or) his wife) averaged about three per farm on the Cattle and Sheep

TABLE IV.

Manual Labour.

(Five Years Averages per Farm).

Type Group.	*Average Size of Farm.*	*Manual Labour.*				
		Hired Labour.	*Farmers' Relatives.*	*Farmer and (or) Wife.*	*Total Persons per Farm.*	*Total Persons per 100 Acres.*
	Acres.	*No.*	*No.*	*No.*	*No.*	*No.*
Cattle and Sheep (Poor Land)	270	1.179	0.889	0.853	2.921	1.084
Cattle and Sheep (Better Land)	115	1.058	0.504	0.920	2.482	2.155
Mixed Farms	80	1.368	0.679	0.574	2.621	3.288
Cattle and Milk	112	1.731	0.461	0.887	3.079	2.741

(Poor Land) and the Cattle and Milk group, and about 2½ persons per farm were on an average employed on the Cattle and Sheep (Better Land) and the Mixed Farm groups. When the manual labour is expressed in terms of persons per 100 acres of land for each of the type groups, the average size of the farm and the quality of the land appears to have some bearing on the number of persons employed. Persons employed per 100 acres averaged about one on the Cattle and Sheep (Poor Land) and two on the Cattle and Sheep (Better Land). The Mixed Farms averaged about 3¼ and the Cattle and Milk farms about 2¾ persons per 100 acres.

The greater proportion of the regular workers are boarded in the farm house though in all the four type groups a small proportion of the workers employed live in farm cottages. On an average the proportion of male to female workers is considerably higher in all the type-groups and the amount of casual labour employed is very small.

Farm Capital.

It must be recognised that there are some difficulties in ascertaining the amounts of capital owned by farmers in general, and this is especially true of the family farm. There are many cases in which the business is carried on without a banking account and it is always difficult to ascertain what amount of cash is available for use as "circulating capital." It is easy to ascertain the amount of capital invested in tenants' fixtures, implements, livestock, crops growing and harvested and stores in hand, or more accurately the current money value of these things. This is the capital represented for the type-groups under consideration for which an analysis is given in Table V. At the same time it does not follow that all the capital is owned by the farmers, nor that this is all the capital available. Some of the capital may have been supplied by dealers and not yet paid for by the farmers. Every effort is made to ascertain the amounts owed to creditors and amounts due from debtors, and when an account is kept for the same farm over a series of years all amounts due from or to the farmers on tradesmen's and similar accounts are fully covered. It is, however, possible that there may be borrowed capital which is undisclosed and this will affect the income of the farmer. This does not, however, affect the capitalisation of the farm except in so far as farms partly stocked with borrowed capital would tend to be slightly undercapitalised. On the whole this capital is owned by the farmer and in the period under review it closely represents the actual owned capital because any excess which is cash or floating capital owned by some of the farmers, would be balanced by debts due from others to tradesmen. The capital represented, therefore, is approximately the current money value of livestock and "deadstock" (implements etc.), tenants' fixtures and crops growing and harvested The figures given in Table V represent the mean of the opening and closing valuations. The principles adopted for valuation are as follows :—Breeding stock, *e.g.*, herds of cows or flocks of ewes are valued on "standard values," which are not changed with temporary changes in market values. The same method was adopted in the case of crops to be consumed by stock

on the farm. In the case of livestock and produce expected to be ready for sale in the year following day of valuation these were valued as nearly as possible to market values. Tenants' fixtures, implements and machinery were depreciated at standard

TABLE V.

Percentage Composition of Capital Invested (Five Years Average).

Type Groups.	*Cattle and Sheep (Poor Land).*	*Cattle and Sheep (Better Land).*	*Mixed Farms.*	*Cattle and Milk Farms.*
Item.	*% to total.*	*% to total.*	*% to total.*	*% to total.*
Horses	9.5	8.8	7.0	7.0
Cattle	31.9	35.8	39.7	44.8
Sheep	29.9	21.6	8.7	8.5
Pigs	1.6	1.8	6.6	2.5
Poultry	1.5	2.2	3.5	1.9
Total Livestock	74.4	70.2	65.5	64.7
Crops and Cultivation	8.8	12.0	11.8	11.8
Implements	16.5	17.5	21.6	22.7
Other items	0.3	0.3	1.1	0.8
Total	100.0	100.0	100.0	100.0
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Total Capital (per Farm)	1044 14 2	938 1 11	917 0 2	1153 2 4
Total Capital (per 100 acres)	387 12 9	814 15 10	1150 5 10	1026 7 10

rates; current repairs, etc., are charged in expenses. Additions to implements are included in expenses, but are then carried to Capital Account.

The average tenants' capital invested per farm does not vary very much as between the type groups. It is highest on the Cattle and Milk group at £1,153 and lowest on the Mixed Farms at £917 per farm. A better comparison of the capital requirements as between the farm-types is obtained when the results are expressed on a per acre basis. The average capital invested on the Cattle and Sheep is £3.8 and £8.1 per acre on Poor Land and Better Land respectively. It is highest on the Mixed Farms at £11.5 while on the Cattle and Milk Farms it is £10.2 per acre. By far the greater proportion of the capital on all the farm-types is invested in livestock, with ranges from nearly 65 per cent. on the Cattle and Milk group to about 74 per cent. of the total capital on the Cattle and Sheep (Poor Land) group. Crops and cultivations account for about 12 per cent. of the total on all the type groups, with the exception of the Cattle and

Sheep (Poor Land) farms at about 9 per cent. Capital investment in implements shows a tendency to increase with the quality of the land and varies as between the farm-types from about 17 to 23 per cent. As might be expected, the Cattle and Milk group have the highest proportion of their capital in cattle and the results indicate that the proportion of the capital invested in sheep decreases from the poorer to the better quality land. Pigs and poultry form but a small proportion of total capital and it is only on the Mixed farms group that pigs reach 7 per cent. of the total capital.

It may be of interest to note the marked differences in the rate of turnover of total capital in the farm-types. In all the groups there is a relatively slow turnover of total capital. It is most rapid in the Cattle and Milk group, but even there it requires about fourteen months for receipts to equal capital. On the Mixed farm group it requires about fifteen months. In the case of the Cattle and Sheep group (Better Land) the rate falls to twenty-one months and it is lowest on the Cattle and Sheep group (Poor Land) at slightly over twenty-two months.

Receipts.

The percentage composition of the receipts for the different type groups averaged over the five years from 1929 to 1934 is shown in Table VI.

The averages for all the groups indicate that livestock and livestock products contributed over 90 per cent. of the total receipts.

For three groups cattle are more important than sheep, but the two items are of nearly equal importance on the Cattle and Sheep (Better Land). The system of farming in which the greatest percentage of sales takes the form of cattle and sheep is found on the Cattle and Sheep (Poor Land) and Cattle and Sheep (Better Land), where 57 and 64 per cent. respectively of the turnover is in this form. On the Mixed farms the turnover in this respect is only 38 per cent. and on the Cattle and Milk farms 29 per cent. The major emphasis on the Cattle and Milk farms is upon dairy produce (mainly liquid milk), which accounts for 50 per cent. of the total sales. Only in this type group does dairy produce assume any importance and if the value of cattle sold is added to that of dairy produce the total represents 68 per cent. of the turnover. For the other type groups, dairy produce represents from about 11 to 14 per cent. of total sales and this is largely in the form of butter. It is only on the Mixed farms that pigs assume any importance, and here they account for

28 per cent. of the receipts and represent the largest single class of farm sales. Other groups are very similar in their turnover in pigs and sales represent about 8 per cent. of the total

TABLE VI.

Percentage Compositon of Receipts (Five Years Average).

Type Groups.	*Cattle and Sheep (Poor Land).*	*Cattle and Sheep (Better Land).*	*Mixed Farms.*	*Cattle and Milk Farms.*
Item.	*% to total.*	*% to total.*	*% to total.*	*% to total.*
Cattle	33.0	32.7	26.0	18.4
Dairy produce	14.1	10.6	12.4	50.0
Sheep and Wool	27.3	31.5	12.1	10.7
Pigs	8.9	8.1	28.0	8.1
Poultry and Eggs	7.4	8.1	10.2	5.1
Horses	5.5	2.4	1.8	1.4
Total Livestock and Livestock Products	96.2	93.4	90.5	93.7
Cereals	0.3	2.2	0.9	0.5
Hay and Straw	0.2	0.6	1.7	0.1
Roots and Potatoes	1.4	1.0	4.5	2.1
Garden Produce	0.0	0.7	0.0	1.3
Sundries	1.9	2.1	2.4	2.3
Total Crops and Sundries	3.8	6.6	9.5	6.3
Total receipts	100.0	100.0	100.0	100.0
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Total Receipts (per Farm)	559 13 3	548 1 6	745 5 0	1013 4 9
Total Receipts (per 100 acres)	207 13 3	476 0 9	934 16 11	901 17 7
	Produce Consumed (already included in Receipts)			
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Per Farm	49 17 8	36 5 1	39 4 5	37 6 9
Per 100 acres	18 10 2	31 9 9	49 4 0	33 4 9

receipts. As regards poultry, the Mixed farms again take the lead and slightly over 10 per cent. of the receipts are obtained from the sales of poultry and eggs. The lowest in this respect is the Cattle and Milk farms, where only about 5 per cent. of the total sales is derived in this way. The other two type groups are very similar in their percentage sales of poultry and average about 7 to 8 per cent. of the total receipts. On the whole the revenue from crops is very small for all the type groups. Only on the Mixed farm group do they amount to 9½ per cent. of total sales. The Cattle and Sheep (Better Land) and the Cattle and Milk farms show receipts from crops amounting to 6 or 7 per

cent. of total receipts. As might be expected the Cattle and Sheep (Poor Land) shows the lowest sales of crops with less than 4 per cent. of total receipts derived from this source. A small quantity of cereals is sold on all the type groups and revenue from this source is highest on the Cattle and Sheep (Better Land) group, while sales of roots and potatoes (mainly the latter) are of more importance on the Mixed farms.

Even though the farms are not fully representative, these figures are evidence of great diversity in price phenomena among farmers in Wales. High or low prices of store cattle and sheep make a substantial difference to the farming turnover in the Cattle and Sheep (Poor Land) group. The price of milk is of serious direct interest only to the Cattle and Milk group. The value of mutton, and possibly of beef, is of chief importance to the Cattle and Sheep (Better Land) group while prices of pigs, poultry and eggs exercise considerable influence on the returns on the Mixed farm group.

Farm Output.

The feeding of cattle, sheep and pigs often involves the purchase of stock in immature condition and a proportion of

TABLE VII.

Percentage Composition of Farm Output (Five Years Average).

Type Groups.	*Cattle and Sheep (Poor Land).*	*Cattle and Sheep (Better Land).*	*Mixed Farms.*	*Cattle and Milk Farms.*
Item.	*% to total.*	*% to total.*	*% to total.*	*% to total.*
Cattle	28.9	29.4	23.4	9.3
Dairy Produce	18.7	13.9	16.7	61.7
Sheep and Wool	25.0	25.4	9.7	6.0
Pigs	9.8	9.0	23.3	8.5
Poultry and Eggs	9.4	11.8	14.4	6.4
Horses	3.6	2.6	0.9	0.6
Total Livestock and Livestock Products	95.4	92.1	88.4	92.5
Cereals	2.4	5.2	8.3	5.4
Sundries	2.2	2.7	3.3	2.1
Total	100.0	100.0	100.0	100.0
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Total Output (per Farm).	459 11 6	419 1 4	554 9 9	820 12 8
Total Output (per 100 acres) ...	170 10 6	363 19 9	695 10 11	730 8 11

their selling value is therefore represented by the price paid for them on purchase. The difference between these two values is the only part of the selling price which has been produced on the farm. For that reason, certain adjustments must be made in the items included in the gross receipts in order to arrive at the *Output* of the farm. In assessing production in the case of livestock the total value of the stock on hand at the beginning of the year plus purchases is deducted from total sales plus the value of the stock on hand at the end of the year. The same method has been used in the case of crops. No deduction has been made for the cost of foods fed to livestock and in the case of crops the cost of seeds and artificial manures have been omitted, because it was not possible, with the data available, to charge these against the various classes of livestock or the different crops or to charge the livestock with the home grown food supplied.

The value and proportional importance of the components of *Output* are shown for each type group in Table VII.

Of the production of livestock the Cattle and Sheep (Poor Land and Better Land) types are very similar in their proportions of output of sheep, wool and cattle, but actual outputs per 100 acres are much higher for the latter type. In the Cattle and Milk group, dairy produce is now shown to be nearly 62 per cent. of the total farm production and cattle only 9 per cent. Pigs are about of equal importance to cattle, sheep and wool, and poultry and eggs each represent about 6 per cent. of the total output. On the Mixed farms the outputs of cattle and pigs are of about equal importance and each accounts for about 23 per cent. of the total production while sheep and wool represents about 10 per cent. Poultry and eggs reached their highest weight in production in this group, where the output is slightly over 14 per cent. The Cattle and Sheep (Poor Land) and the Mixed farms are very similar in output of dairy produce (19 and 17 per cent. respectively) while only 14 per cent. of the production is accounted for in this manner on the Cattle and Sheep (Better Land) farms.

Examination of the group figures in Table VII will show that specialisation in production is exhibited only in a very general way; in only one out of the four type groups does any class of product account for as much as 62 per cent. of the total production.

Farm Expenses.

The percentage composition of the expenses in the different type groups averaged over the five years from 1929 to 1934 is shown in Table VIII.

The comparative simplicity of the farming under the first two type groups is clearly indicated by the relatively high proportions of expenses, which are attributable to land and labour.

TABLE VIII.

Percentage Composition of Expenses (Five Years Average).

Type Groups.	*Cattle and Sheep (Poor Land).*	*Cattle and Sheep (Better Land).*	*Mixed Farms.*	*Cattle and Milk Farms.*
Item.	*% to total.*	*% to total.*	*% to total.*	*% to total.*
Rent	18.5	20.5	15.9	16.2
Rates	1.2	1.2	0.9	1.3
Wages (Hired)	18.7	17.9	14.9	18.6
Wages (Family)	13.2	7.8	7.3	3.1
Total Labour	31.9	25.7	22.2	21.7
Feedingstuffs	15.4	12.8	22.9	23.9
Manures	2.6	1.9	1.6	1.7
Seeds	1.6	1.5	2.1	1.2
Implements	2.4	3.5	2.0	4.2
Sundries	8.5	6.0	6.3	7.1
Total Direct Expenses	82.1	73.1	73.9	77.3
Horses	3.0	0.9	1.3	1.1
Cattle	9.4	12.8	8.5	14.5
Sheep	4.0	12.0	4.2	5.1
Pigs	1.2	0.8	11.7	1.7
Poultry	0.3	0.4	0.4	0.3
Total Livestock	17.9	26.9	26.1	22.7
Total Expenses	100.0	100.0	100.0	100.0
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Total Expenses (per Farm)	478 2 8	503 6 0	717 2 5	852 7 4
Total Expenses (per 100 acres)	177 8 3	437 2 9	899 11 2	758 13 10

For the Cattle and Sheep group (Poor Land and Better Land) the rent averaged 18½ and 20½ per cent. respectively of the total expenses. It is approximately the same, at 16 per cent., on both the Mixed farms and the Cattle and Milk group. While labour constitutes a high proportion of the total expenditure, it does not in all the farm-types account for the largest item of actual cash expenses in the cost budget. The proportion of labour costs to total expenses tends to fall as the standard rises in the various type-groups from the poorer to the better land; *i.e.*, as the total expenses and total revenue rise the proportion of labour costs in the total expenses tend to fall. The reasons for this tendency towards lower proportion of labour costs to total expenditure,

with rise of the standard of farming from type-group to type-group is generally that as the standard rises there are increases in the amounts and proportion of expenditure on such items as feedingstuffs, fertilisers, seeds and capital maintenance. These increases depress the proportions of expenditure on labour.

The proportion of labour to total expenses is shown as two items (1) hired labour for which wages are paid; (2) family labour for which a charge is made according to current rates of wages of hired workers. The latter item does not include any charges for the work of the farmer or his wife, but includes charges for the work of all relatives. From the figures giving the percentage composition of expenses in Table VIII it will be seen that the proportion of family labour to that of total labour shows a tendency to decrease with the quality of the land, and the proportion of total labour to total expenses decreases gradually on the type-groups from 32 per cent. on the Cattle and Sheep (Poor Land) farms to about 22 per cent. of the total expenses on the Cattle and Milk farms. Feedingstuffs is a fairly heavy cost item on all the type-groups, being actually more important than labour on the Mixed and Cattle and Milk groups. On the Cattle and Sheep (Poor Land and Better Land) feedingstuffs represent about one-half the cost of total labour. There is very little variation from group to group in the proportion of manures to total expenses except that they are slightly higher on the Cattle and Sheep (Poor Land) group. Manures only represent a small proportion of total expenses and even with the cost of seeds, these two items together only account for about 3 to slightly over 4 per cent. of the total expenses on the different type groups. Next to labour and feedingstuffs the most considerable item of expense for all the type groups is the purchase of livestock. The proportion which this item bears to the total expenses is lowest on Cattle and Sheep (Poor Land) farms (about 18 per cent.) For the other farm-types the proportions vary from about 23 per cent. to 27 per cent. of the total expenses. Of purchases of livestock, cattle are the most important item and with the exception of the Mixed Farm group, account for about one-half of the total in each group. Purchases of sheep appear to be heaviest on the Cattle and Sheep (Better Land) group where they represent 12 per cent. of the total expenses. Other type-groups show a variation of from 4 to 5 per cent. of total expenditure. It is only on the Mixed farm group that the purchase of pigs is of major importance. On this group they account for nearly 12 per cent. of the total expenses. On the other type-group pigs represent from less than 1 per cent. to about 2 per

cent. of the total expenditure. Horses and poultry are not very important items of expense in any of the type-groups.

Financial Results.

The incomes from the farms are considered in three ways and the statements of income need full understanding of the methods of calculation. *Gross income* includes all the earnings of the farm family, profits as usually understood, wages of sons and daughters carried on the farm, value of produce consumed, and enjoyment of house. *Farm income* excludes wages of sons and daughters, but includes value of produce consumed and enjoyment of house. It represents the "profits" to the occupier (the farmer and his wife) and is in fact the difference between receipts and expenses plus or minus valuation difference. But as the *farm income* includes what is in effect payment to the farmer and often in part to his wife for manual labour done, the further calculation of *labour income* is made. This is farm income minus allowance for interest on capital at the rate of 6 per cent. per annum. This *labour income* is then the earnings of the farmer and his wife in manual labour and management on the farm.

It is felt that these separate calculations of income in different forms are necessary and useful in an understanding of the complete conditions of determination of standard of living on farms. The gross (family) income represents the values consumed and available for consumption for the family. The amount per head will vary according to the size of the total family, which will not be the same as the number of farm workers. Farm income represents the value consumed and available for consumption to the farmer and his wife (and to other non-working members of family) when wages have been paid to working relatives.

The financial results for the farm-types in terms of gross income, farm income and labour income are stated in Table IX.

For the *Cattle and Sheep (Poor Land) farms*, the group incomes tend to be low and over the five years the average *gross (family) income* per farm in the group was only £126, the average *farm income* to the farmer and his wife was £64, and when interest on capital has been allowed the *labour income* was only £2. The year 1930-1 was a poor one for these farms, but they suffered most after the disastrous slump in prices of sheep in the autumn of 1931, and 1931-2 and 1932-3 were both years of very low returns when no *farm income* was obtained. Conditions

improved for this group in 1933-4 when a *farm income* of £84 and a *labour income* of £26 was shown.

Cattle and Sheep (*Better Land*). Again incomes throughout the group have been small during the last five years, and particularly during the years from 1931 to 1934. Over the whole period the *gross income* was £92 and the *farm income* £53 and no *labour income* was obtained. The whole group continue to suffer more than other type groups because of their greater reliance on cattle and the continuation of depression in the cattle markets.

Mixed Farms. An average *gross income* of £74 and a *farm income* of £22 is shown for this group but no *labour income.* The

TABLE IX.

Gross Income. Farm Income and Labour Income.

(Per Farm and per 100 Acres).

Year.	*Per Farm.*			*Per 100 Acres.*		
	Gross Income.	*Farm Income.*	*Labour Income.*	*Gross Income.*	*Farm Income*	*Labour Income.*
	CATTLE AND SHEEP (POOR LAND).					
	£	£	£	£	£	£
1929–30	259	187	127	110	80	54
1930–1	201	137	67	82	56	27
1931–2	60	11*	84*	23	4*	32*
1932–3	2	53*	110*	1	18*	37*
1933–4	132	81	26	44	27	9
Average (5 years)	126	64	2	47	24	1
	CATTLE AND SHEEP (BETTER LAND).					
1929–30	216	160	93	165	122	71
1930–1	211	167	112	191	152	101
1931–2	16	24*	86*	13	20*	72*
1932–3	33	6	45*	30	5	41*
1933–4	38	0	51*	32	0	45*
Average (5 years)	92	53	3*	80	46	3*
	MIXED FARMS.					
1929–30	105	55	12	134	70	16
1930–1	110	79	20	135	97	25
1931–2	84	28	29*	109	36	37*
1932–3	13	42*	102*	15	50*	122*
1933–4	70	6	48*	90	8	63*
Average (5 years)	74	22	35*	93	27	42*
	CATTLE AND MILK FARMS.					
1929–30	326	297	236	385	351	280
1930–1	220	192	136	193	168	120
1931–2	119	167	97	159	140	82
1932–3	102	73	2	95	68	2
1933–4	235	211	134	189	169	107
Average (5 years)	198	172	103	176	153	91

* Minus Quantities.

depression began to be felt on this group in 1931-2 and has continued more or less up to 1933-4. This group was affected to a marked degree by the low prices ruling for pigs during the years from 1931 to 1933 and the decline in the prices of eggs and butter.

Cattle and Milk. The year 1932-3 proved to be the worst for this group, for in every other year the group as a whole obtained real income. Over the five years the *gross income* on this group was £198, the *farm income* £172 and the *labour income* £103 per farm.

Changes in the Level of Income and Expenses.

During the period under review the general agricultural index figure fell from 139 to 113, but the price changes that have occurred have varied widely for different commodities. The nature of the business of agriculture is such that farmers cannot immediately change their farming methods or systems to meet changes in the market conditions. It is mainly in these changes, therefore, that explanation must be sought for the differing levels of reward earned by the various groups of farmers. The index numbers for the "crop year" published by the Ministry of Agriculture indicate that up to 1931 prices of sheep had declined less rapidly than prices of most other commodities and the trend of the sheep trade up to that time had been such as to make sheep farming fairly profitable. Prices of sheep fell considerably in 1931 and the demand for store sheep in 1932 was rather poor and although a fair trade was experienced in the spring and autumn sales the level of prices was exceptionally low. Generally speaking sheep farmers during 1931-2 and 1932-3 were losing badly and especially those farmers who depended on the autumn sales of store sheep and cattle for the greater part of their yearly revenue. Apart from store cattle, fat and store sheep, all classes of pigs and wool were realising much lower prices than during the period from 1929 to 1931. While conditions improved in 1933-4 and prices of store and fat sheep showed some recovery from the low levels of the previous years, the store and fat cattle trade showed no signs of improvement and in general prices of these classes of stock were lower than in the previous year. Wool has remained at under pre-war values since 1929-30 but a substantial increase in wool prices occurred during 1933-4 and prices of wool are still improving. With regard to other farm products, prices of poultry and eggs showed a downward trend from 1929-30 to 1933-4. Butter prices also showed a gradual decline over the same period and during the years from 1932 to 1934

stood at below pre-war levels. Cheese prices have also shown similar tendencies. Prices of milk fell between the years 1929-30 and 1931-2, but prices improved during 1932-3 and again in 1933-4. In the case of potatoes, the year 1932-3 was unusual on account of the persistently low level of prices then shown and which continued into 1933-4. Barley prices stood at about pre-war values during the years from 1930 to 1932, and at below pre-war values in 1932-3. Some recovery was made in 1933-4 when the index figure for barley was 12 per cent. above pre-war level. Oats and wheat have declined in prices over the whole period and now stand at under pre-war values, but in the case of wheat this does not include the subsidy granted to the grower under the Wheat Act.

Some items of farm expenses show a tendency to decrease. Feedingstuffs prices have on the whole shown a downward trend.

TABLE X.

Index Numbers for Crop Years.* Base 1911-13 = 100.

Commodity.	*Crops Years (September-August).* 1929-30	1930-1	1931-2	1932-3	1933-4
General agricultural produce ..	139	125	114	106	113
Wheat	116	79	79	74	63
Barley	103	100	101	92	112
Oats	94	86	101	82	82
Potatoes	91	162	230	108	107
Hay	132	93	73	67	82
Fruit	157	119	132	178	142
Vegetables	147	141	158	130	163
Fat Cattle	134	126	118	103	100
Store Cattle	123	127	118	101	86
Dairy Cows	132	129	119	109	105
Fat Sheep	160	147	110	103	120
Store Sheep	155	146	92	80	95
Bacon Pigs	162	121	92	96	112
Pork Pigs	172	138	102	102	120
Store Pigs	126	136	110	109	142
Poultry	149	148	133	127	121
Eggs	148	125	110	107	103
Milk	164	159	139	147	161
Butter	140	114	106	94	91
Cheese	135	119	124	114	107
Wool	82	52	45	66	80
Feedingstuffs	110	82	94	88	84
Fertilisers	101	100	90	89	90

* From the Ministry of Agriculture and Fisheries Agricultural Market Reports.

and in 1933-4 were 16 per cent. below pre-war cost. Artificial manures have also moved in a similar manner and show a reduction of about 10 per cent. on the pre-war costs. While no

general figures are available for agricultural wages but from the wages rates fixed under the Agricultural Wages (Regulation) Act, 1924, cost of farm labour would be somewhere between 60-70 per cent. above pre-war level. Agricultural implements, seeds and other farm materials would be considerably higher than pre-war costs.

While there are signs of improvement in the prices of some farm commodities during 1934-5 this is not common to all. The index numbers for the "crop year," 1934-5, indicate some improvement in the prices of store and fat sheep and also wool. Other livestock do not show the same trend. Prices of fat cattle (excluding the beef subsidy) and dairy cows were lower in 1934-5 than in the previous years and there was hardly any improvement in the store cattle trade. Bacon pigs, porkers and store pigs declined in price. The market for dairy produce (butter and cheese) during 1934-5 showed no improvement and prices were even lower than in the previous year, but milk prices showed a decided increase. Poultry prices showed a slight decline while prices of eggs hardened a little.

On the whole the indications are that the financial position on all the type-groups will show some improvement during 1934-5, with possibly the exception of the Cattle and Sheep (Better Land) group.

COMPARATIVE PRODUCTIVITY AND INCOME YIELD OF SMALL HOLDINGS AND FARMS IN WALES, 1929-34.

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The accounts of a fairly normal and representative group of small holdings and farms in Wales over a period of five years, 1929 to 1934, provide some evidence on the comparative productivity of the small, medium size, and larger holdings. The period was one of "depression," and in the central years no type or general size of farms commonly earned normal profits. In such periods small holdings and small farms generally appear to have some advantages over the larger farms in maintenance of capital and possibly of earnings, but certainly in the factors which make for general stability in a period of rapid falls in prices and changes in the ratios of prices of requirements of production and prices of products. There is evidence of these conditions of advantage in the accounts analysed and in a more "normal" period, or

one of more general economic stability, results might not prove to be the same as those now presented.

Although it is often assumed that measurement of productivity per acre of land is sufficient to prove their efficiency or social value the accurate measurement of productivity of small holdings is not a simple matter. Small holdings, like all farms, employ land, capital, and labour, and each supply has to be paid for; and probably, in the long run, paid for at rates quite as high as are paid for similar supplies or combinations of supplies for larger farms. Hence, as far as may be possible, measurements of productivity should indicate the productivity of capital and labour as well as that of land.

The groups of holdings dealt with are as follows :—

Group.	*Range in Acres.*	*Average Size. Acres.*
1	Up to 49	39
2	50 — 99	74
3	100 — 149	120
4	Over 149	283

Holdings of these sizes, although all are engaged almost wholly in livestock production, use land, labour, and capital in different combinations and proportions. The small holdings use relatively high amounts of capital per acre and fairly high amounts of capital in relation to rents, but lower amounts of capital per person than the large farms.

Group.	*Capital per Acre.*	*Capital per Person.*	*Capital per £100 Rent and Rates.*
	£ s. d.	£	£
1	12 10 7	256	923
2	9 4 5	278	903
3	9 16 5	396	726
4	5 7 2	442	890

The amount of capital per person engaged is significant, for it means that on the smaller holdings manual labour is used for some purposes for which other forms of power—horse or mechanical—are used on larger farms. On the whole, it appears that the small holdings are generally as well capitalised as the larger farms, even though some forms of investment are restricted by the natural desire to use the available labour. There are some cases in which increased investment to save labour would add to costs rather than reduce them.

Investment of capital in relation to quality of land is somewhat higher on the smaller than the larger holdings, and this higher investment is largely to be found in livestock. The small holder needs to use his land more intensively in order to obtain a full wage for his labour and a modicum of interest on his capital.

The amount of labour per 100 acres of land and per £100 rent, shows that relatively high amounts of labour are used on the smaller holdings.

Manual Labour.

roup.	*Persons per 100 acres.*	*Persons per £100 Rent and Rates.*
1	4.89	3.620
2	3.33	3.249
3	2.48	1.832
4	1.21	2.016

On the whole, the smaller holdings appear generally to be situated on land which is of higher than average quality. Rents per acre are higher :—

Rent and Rates per Acre.

Group.	*£*	*s.*	*d.*
1	1	7	6
2	1	2	2
3	1	7	0
4	0	12	0

When allowance has been made for the higher proportion of the annual value of houses and buildings in rents of small holdings, and for somewhat keener competition between potential occupiers of small than of larger holdings, there are still

Gross Receipts (Production).

Group.	*Per 100 Acres.*	*Per £100 Rent and Rates.*
	£	£
1	938	690
2	697	678
3	766	568
4	355	588

indications that on the whole the small holders have the better opportunties of achieving relatively high production per acre of land. The gross receipts, which equal sales and value of products

consumed in the farm households, used as a measure of gross production, show the apparent higher productivity of small holdings, but attention should be given to the diminution of the differences in productivity when allowance is made for differences in quality of land as measured by rents.

While the smaller holdings show some advantages (or it is sometimes suggested, some economic virtues) in the use of land, they show considerable disadvantages in the use of labour. As the amount of labour falls per 100 acres of land, the production —as measured by gross receipts per person shows important increases.

Group.	*Persons per 100 Acres.*	*Gross Receipts per Person.*
		£
1	4.89	192
2	3.33	209
3	2.48	309
4	1.21	293

The amount of labour shown by number of persons per 100 acres includes only manual labour as no " management " labour is included. The amount of management labour is somewhat higher per holding on the larger farms, and possibly also slightly higher per 100 acres, but there is very little qualification of the results to be allowed, and the larger farms definitely use labour to the better advantage and make the most effective use of it in production.

Again, in the use of capital, such differences of advantages as can be seen lie with the larger farms, but in this case the differences are slight.

Group.	*Gross Receipts per £100 Capital.*
	£ s. d.
1	74 16 0
2	75 4 0
3	78 2 0
4	85 12 0

It may be noted that these figures also represent the rate of turnover of capital on farms of these sizes; namely, about 75 per cent. per annum on the smaller holdings and about 86 per cent. per annum on the larger.

These figures for production, as measured by gross receipts, have been related to the factors of production—land, labour, and

capital—as used in the more or less fixed combination which is determined when the type of farming is chosen and the available capital is invested. They show advantages to small holdings in use of land and disadvantages in use of capital and labour. However, the farmers are continually making short-period investments either of free (or floating) capital remaining in cash after the fixed investment has been made, or of receipts by sale of produce, or of credit, used as circulating capital for the purchase of the requirements of production.

In the use of short period investment, as indicated by expenditure on feeding stuffs and fertilisers, the small holdings show quite different results than in the case of the fixed capital investment. When allowance is made for the different qualities of land the small holding show the lower expenditures on these raw materials.

Expenditure on Feedingstuffs and Fertilisers.

Group.	*Per 100 Acres.*	*Per £100 Rent and Rates.*
	£	£
1	259	53
2	139	74
3	140	96
4	64	94

The small holdings, however, show a higher turnover on the short period investment and higher sales of livestock and livestock products per unit of expenditure on feedingstuffs and fertilisers.

Group.	*Gross Receipts per £100 Expenditure.*	*Net Sales of Livestock and other Products per £100 Expenses on certain Raw Materials.*
	£ s. d.	£
1	180 14 0	110
2	119 8 0	94
3	118 14 0	80
4	108 8 0	75

Throughout the processes of combination of land, labour and capital for production, and generally in production as shown by the use of the chief raw materials, the small holders are seen to be using their land far more intensively than the larger farmers. They have both the higher inputs and the higher outputs. They are using capital slightly more extensively per unit of land (area, and quality as measured by rent), and labour far more extensively.

But, as will be shown, they have not earned more than the wages of adult farm workers and some interest on their capital.

TABLE I.

Returns to Labour and Capital on Holdings of Different Sizes.

Size Group.	*Wages paid to Employees.*		*Wages paid or due to Relatives (mainly sons and daughters).*		*Wages due to Farmer and Wife at £80 per annum.*		*Earnings of Capital.*		
							Capital.	*Earnings.*	*Rate %*
Column.	1	2	3	4	5	6	7	8	9
Per Holding. Acres.	*No. of Persons.*	£ s. d.	*No. of Persons.*	£ s. d.	*No. of Persons.*	£ s. d.	£ s. d.	£ s. d.	%
Up to 49	0.786	48 1 7	0.122	6 6 10	1.050	84 0 0	489 3 2	7 9 3	1.52
50-99	1.052	86 18 2	0.541	37 3 7	0.873	69 16 10	686 8 10	19 6 4	2.81
100-149	1.684	154 11 5	0.501	34 3 8	0.786	62 17 7	1176 8 6	27 4 1	2.31
Over 149	1.764	150 4 5	0.988	71 1 11	0.697	55 15 2	1522 19 0	22 2 10	1.45
Per 100 acres Acres.									
Up to 49	1.88	123 4 10	0.310	16 5 1	2.700	212 15 3	1253 0 0	19 2 6	1.52
50-99	1.41	116 16 3	0.720	49 19 5	1.180	93 17 1	923 0 0	25 19 1	2.81
100-149	1.41	129 0 5	0.410	28 10 8	0.660	52 9 9	980 0 0	22 14 1	2.31
Over 149	0.62	53 0 0	0.350	25 1 8	0.240	19 13 8	538 0 0	7 16 3	1.45

The incomes arising from these holdings are displayed both " per holding " and " per 100 acres " in Table I.

The total earnings of the average farmer (and his wife, if engaged in any manual labour) in each group are :—

Group.	Wages of Labour due to Farmer and his wife (at £80 per annum).	Earnings of Capital.	Total Earnings.
	£ s. d.	£ s. d.	£ s. d.
1	84 0 0	7 9 3	91 9 3
2	69 16 10	19 6 4	89 3 2
3	62 17 7	27 4 1	90 1 8
4	55 15 2	22 2 10	77 18 0

Thus in a period of five years, 1929-34, one of depression, the occupiers of the largest farms have made the smallest incomes. The advantages as between the other groups lie with the small holders but the differences are so slight as to be insignificant.

When wages are allowed for manual work done by the farmer and (or) his wife at the rate of £80 per annum for actual time worked (about the rate of wages of employed manual workers) the rate of earnings of capital (rate of interest) is as shown in column nine of Table I. On the other hand, if interest is allowed on capital at 6 per cent. per annum, the earnings of the farmer and (or) his wife in labour and management are very small.

Group.	Earnings of Farmer in Labour and Management (after allowing interest on Capital at 6 per cent.).	Or Earned Interest on Capital (allowing wages for labour of Farmers, etc.).
	£ s. d.	%
1	62 2 3	1.52
2	47 19 6	2.81
3	19 12 8	2.31
4	— 13 12 2*	1.45

* In this case interest on capital at 6 per cent. requires £91 10s. 2d., while total earnings only amount to £77 18s. 0d.

If earnings of capital are made the criterion of efficiency, of success, or of social value, then for this period the second group of holdings, averaging seventy-four acres and £76 rent, show the best results, while the largest holdings show those which are least satisfactory.

In the interpretation of these figures, and in the actual results of farming, a great deal of the advantage which appears

to lie with the small farmer arises from his own (and often his wife's) contribution to labour, that is in "paying wages to himself." The constitution of the "labour force" on these groups of holdings is as follows :—

Labour per Holding.

Group.	*Employees.*	*Farmers' Relatives.*	*Farmer and Wife.*	*Total. Persons.*
1	0.786	0.122	1.050	1.908
2	1.052	0.541	0.873	2.466
3	1.684	0.501	0.786	2.971
4	1.764	0.988	0.697	3.449
		Per cent.		
1	38.58	6.39	55.03	100
2	42.66	21.94	35.40	100
3	56.67	16.88	26.45	100
4	51.14	28.65	20.21	100

While the distribution of "wages" to labour is :—

Total "Wages" to Labour.

Group.	*Employees.*	*Farmers' Relatives.*	*Farmer and Wife.*	*Total Persons.*
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1	48 1 7	6 6 10	84 0 0	138 8 5
2	86 18 2	37 3 7	69 16 10	193 18 7
3	154 11 5	34 3 8	62 17 7	251 12 8
4	150 4 5	71 1 11	55 15 2	277 1 6
		Per cent.		
1	24.74	4.58	60.68	100
2	44.82	19.17	36.01	100
3	61.42	13.59	24.99	100
4	54.22	25.66	20.12	100

In this connection the high proportion of work done by farmers' relatives on the largest farms is noteworthy. If these farmers "pay little wages to themselves," they pay or owe relatively large amounts to relatives. The total "family labour" and "family incomes" for each group shows that the families on the largest farms enjoyed the largest incomes because these farms provided the widest opportunity for the use of family labour.

The income yield of farming, however, is not limited to the income accruing to the farmer and his family, or even to that accruing to all labour. Broadly viewed, the income arising from farming consists of wages of employed labour and rent of land, both paid on contract; earnings paid or due to farmers' relatives, and finally the income obtained by the farmer himself. As

displayed in these results of analyses of accounts, all these forms of income except rents are "net," and available for the personal use of the recipients. In the case of rent, allowance has to be made for repairs and upkeep of property and for costs of management and administration. There is no definite information on the

Family Labour and Family Earnings per Holding.

Group.	*Family Labour.*			*Earnings.*		
	Farmers' Relatives.	*Farmer and Wife.*	*Total Family in Manual Labour.*	*Relatives.*	*Farmer and Wife (Labour and Capital)*	*Total Family Income.*
				£ s. d.	£ s. d.	£ s. d.
1	0.122	1.050	1.172	6 6 10	91 9 3	97 16 1
2	0.541	0.873	1.414	37 3 7	89 3 2	126 6 9
3	0.501	0.786	1.287	34 3 8	90 1 8	124 5 4
4	0.988	0.697	1.685	71 1 11	77 18 0	148 19 11

actual proportion of gross rents which is expended on maintenance and management of property. If, however, gross rent is for the time being taken as income, the total incomes arising from farming operations are as in column 7 of Table II.

The distribution of the total income of the agricultural group concerned with these holdings may be displayed in two ways, namely by making farming capital the residual claimant,

and then by making " profits "—or otherwise the farmer and his capital—the residual claimant.

TABLE II.

Incomes arising from Holdings of Different Sizes.

Size Group.	*Manual Labour.* *Employees.*	*Farm Family.* *Relatives.*	*Farm Family.* *Occupier and Wife.*	*Total Income arising from manual labour.*	*Capital and Land.* *Earnings of Capital.*	*Capital and Land.* *Rent of Land (Gross).*	*Total Income.*
Column.	1	2	3	4	5	6	7
Per Holding Acres.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Up to 49	48 1 7	6 6 10	84 0 0	138 8 5	7 9 3	48 12 5	194 10 1
50-99	86 18 2	37 3 7	69 16 10	193 18 7	19 6 4	68 18 11	282 3 10
100-149	154 11 5	34 3 8	62 17 7	251 12 8	27 4 1	154 10 5	433 7 2
Over 149	150 4 5	71 1 11	55 15 2	277 1 6	22 2 10	161 11 4	460 15 8
Per 100 acres Acres.							
Up to 49	123 4 10	16 5 1	212 15 3	352 5 2	19 2 6	125 18 3	497 5 11
50-99	116 16 3	49 19 5	93 17 1	260 12 9	25 19 1	92 13 4	379 5 2
100-149	129 0 5	28 10 8	52 9 9	210 0 10	22 14 1	128 19 7	361 14 6
Over 149	53 0 0	25 1 8	19 13 8	97 15 4	7 16 3	57 0 1	162 11 8

The proportions to rent and labour are each very nearly equal in the first two groups, and at a lower level again very nearly equal for the groups of larger holdings. The proportion to farming capital is naturally somewhat higher for the larger farms where capital itself constitutes a higher proportion of total input.

Arranged in this form, the proportions to wage-paid labour naturally tend to rise with the size of holding. The proportion to the occupier, for manual labour, capital and management, is

Distribution of Total Income per 100 Acres (Farming Capital as Residual Claimant).

	Labour.	*Capital.*	*Rent.*	*Total.*
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Up to 49 Acres	352 5 2	19 2 6	125 18 3	497 5 11
%	70.83	3.85	25.32	100.00
50- 99 ,,	260 12 9	25 19 1	92 13 4	379 5 2
%	68.72	6.85	24.43	100.00
100-149 ,,	210 0 10	22 14 1	128 19 7	361 14 6
%	58.07	6.27	35.66	100.00
Over 149 ,,	97 15 4	7 16 3	57 0 1	162 11 8
%	60.13	4.81	35.06	100.00

influenced largely by the proportion of the occupiers' time given to manual labour with the consequent saving of wages. As previously explained, the high proportion of time given to

Distribution of Total Income per 100 Acres (Profits as Residual Claimant).

	Wage Paid Labour (Employees and Relatives).	*Occupier (Farm Income).*	*Rent (Gross.*	*Total.*
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Up to 49 Acres	139 9 11	231 17 9	125 18 3	497 5 11
%	28.05	46.63	25.32	100.00
50- 99 ,,	166 15 8	119 16 2	92 13 4	379 5 2
%	43.98	31.59	24.43	100.00
100-149 ,,	157 11 1	75 3 10	128 19 7	361 14 6
%	43.56	20.78	35.66	100.00
Over 149 ,,	78 1 8	27 9 11	57 0 1	162 11 8
%	48.03	16.91	35.06	100.00

manual labour by occupiers of small holdings affects their incomes, and here it exercises a big influence on the distribution of total income. The proportion of income in respect of land, in rent, is about equal for the first two groups and again at a higher level for the other two.

On the general economic conditions, it may be said that the supply and use of labour is the dominating factor in the economy of Welsh farming. Labour is relatively plentiful and there is a tendency to use it in what appear to be, and sometimes are, uneconomical ways. Capital, whether in fixed or floating forms, is relatively scarce. Consequently the general standard of production tends to be low. There is evidence to the effect that

farming would be more profitable, even under some conditions of depression, if it were more intensive and if production were carried to a higher level. Or, in other and more practical terms, if more capital were associated with labour in the form of more and better feedingstuffs and more particularly fertilisers and seeds;[1] and possibly to some extent in better equipment of land with drainage and buildings for greater and better production. There is indeed clear evidence that those farmers who associate the higher supplies of feedingstuffs, fertilisers and seeds with the supply of labour at their command not only raise their production but increase their profits in the process.

Under the conditions prevailing in the five years under consideration the small holders, as far as their position is shown by these accounts, have stood out firmly in the general agricultural community. In comparison with other occupiers they have a high standard of production; they use their capital to good effect, and they have maintained their incomes at relatively high levels. If they do this largely by intensive application of manual labour, this has always been and will remain one of the conditions of success on the general run of small holdings. Their manual labour earns for them the wages of adult and normally skilled farm workers, but whether these wages are for rather more work—in time and intensity—than would be given by a normal employee in a year, must remain an open question. They have also managed to earn about 1½ per cent. on their capital during the depression. In normal times, perhaps, they may expect to earn an average of 5 per cent. or a little more, in addition to the wages for manual labour, but it is clear that saving cannot be very rapid unless at certain periods the family is content to reduce consumption to fairly low levels, or a son or daughter is willing to work and pool wages for saving capital in the expectation of postponed participation in both ownership of the capital and its benefits. But, as already seen, the economic welfare of small holdings depends to an appreciable extent on the contribution of the occupier's wife to manual labour, and to a certain extent the difference between the position of the small holder and that of the farm worker in regular employment is due to the economic opportunities of the small holder's wife. Whether there are any secondary effects on the family of this agricultural use of female labour is not now a subject of general

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[1] Ashby: "Does the Higher Farming Pay?" *Welsh J. of Agri.*, Vol. 7, 1931.

Jones: A Statistical Analysis of Farm Accounts. *J. of Farm Economics*, Vol. 16, No. 4 (October, 1934).

enquiry, but it may certainly be said that in the case of the women of small holdings they work much harder than wives of farm workers and that in at least some cases households and families suffer as a consequence.

TEN YEARS' RESULTS OF A POULTRY FARM IN WALES.

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It is well known that since 1931 the profitability of poultry enterprises has declined sharply. The chief cause is to be found in the relationship between the prices paid for feeding stuffs and the prices received for market eggs. Foods represent about 60 to 70 per cent. of the total cost of laying flocks, whilst revenue from the sale of market eggs accounts for from 60 to 70 per cent. of the total income. A useful indication of the profitability of the poultry at different dates can be obtained by comparing the market price per 120 ordinary eggs with the cost of one cwt. of poultry food. The wider the margin between the values of these quantities of the two items the greater will be the surplus to meet other production expenses, which amount to only one-third of the total.

Between the years 1927 and 1931 the cost of foods fell more rapidly than the market prices for eggs, with the result that there was an increasing margin from which to meet minor current expenses. In 1927 the indices of feeding stuffs and egg prices were thirty-nine and forty-five points respectively above the 1911-3 level, but by 1931 the index for foodstuffs had fallen by fifty-six points to eighty-three, seventeen points below the 1911-3 level, while the index of egg prices fell from 145 to 116. Since 1931 the margin has narrowed considerably and in 1934, the most difficult year for poultry farmers, the indices of prices for eggs and feeding stuffs were 102 and ninety-one respectively. During 1935 prices of market eggs improved by seven points while prices of foods fell four points. The general position is shown in the following summary of the indices of prices for eggs and foodstuffs for the period 1924-35.

Indices of Prices of Market Eggs and Foodstuffs for the period 1924-35. (1911-3=100).

Years.	*Indices.*		*Difference.*
	Eggs.	*Foodstuffs.*	
1924	168	154	14
1927	145	139	6
1931	116	83	33
1934	102	91	11
1935	109	87	22

The financial records of a poultry farm in Wales covering the ten years 1926-35 show clearly the decline in the profitability of poultry during the last few years. But what is more interesting, they show how this farmer avoided much of his own difficulty by diverting as many eggs as was possible from the ordinary market.

The ten years may be conveniently divided into three main periods. During the first three years, 1926 to 1928, a period of relatively high and steady prices of eggs, the farmer concentrated upon building up a flock of high quality birds from which to sell hatching eggs and day-old chicks. For the next four years, a period of falling prices of market eggs, the flock of laying birds numbered from 450 to 500 and the revenue from hatching eggs and day-old chicks reached its maximum. In 1933 there was a change of location, with some disorganisation, but since then concentration has again been diverted mainly to building up a fresh flock but sales of hatching eggs and day-old chicks have provided an important part of the gross income.

The following table shows the sources of current income and items of expenditure for each of the three main periods. During the first two periods no hired labour was employed on the poultry but a charge for labour has been included in current expenditure in order to permit comparisons with the last period when hired labour was employed.

The sale of (fresh) market eggs has accounted for the most important part of the gross receipts in all years, but the importance of this source of revenue has declined from 68.8 per cent. in 1926-8 to 58.8 per cent. in 1933-5. Income from the sale of hatching eggs has increased in amount and in its importance as part of the total gross receipts. In the three years 1926-8 it amounted to 2.9 per cent., in 1929-32 6.2 per cent., and although no hatching eggs were sold in 1933 sales in the next two years amounted to 10.6 per cent. of the gross income for the three

Cash Receipts, Expenses and Net Profits.

	3 Years, 1926–8 inclusive.	4 Years, 1929–32 inclusive.	3 Years, 1933–5 inclusive.
	£ s. d.	£ s. d.	£ s. d.
Market Eggs	981 14 6	1318 4 9	726 5 6
Preserved Eggs	166 10 0	—	—
Hatching Eggs	41 5 9	136 14 6	128 1 6
Day old Chicks	121 12 4	664 6 6	278 1 0
Table poultry, old hens and young cockerels	101 11 6	64 11 6	67 18 6
Stock birds and pullets	12 14 6	17 10 0	13 6 0
Other Receipts	1 5 0	15 1 0	7 3 0
Gross Loss	—	—	78 16 9
	1426 13 7	2216 8 3	1299 12 3

	3 Years, 1926–8 inclusive.	4 Years, 1929–32 inclusive.	3 Years, 1933–5 inclusive.
	£ s. d.	£ s. d.	£ s. d.
Foodstuffs	685 6 6	768 10 0	729 17 0
Labour: Hired	—	—	170 0 0
Family	250 0 0	400 0 0	120 0 0
Horse	75 0 0	100 0 0	—
Marketing	25 3 6	68 1 3	38 10 0
New Stock and Hatching Eggs	11 8 0	37 7 6	77 19 6
Vets Blood Testing and Disinfectant	14 0 9	22 7 6	33 13 3
Paraffin	19 4 11	61 11 4	49 0 3
Litter	29 7 6	42 15 0	21 5 6
Rent	16 1 0	21 8 0	34 0 0
Preserving Expenses	7 5 9	—	—
Repairs and Sundries	21 1 5	60 13 10	25 6 9
Gross Profit	272 14 3	633 13 10	—
	1426 13 7	2216 8 3	1299 12 3

	Jan., 1926.	*Jan.*, 1929.	*Jan.*, 1933.
	£ s. d.	£ s. d.	£ s. d.
Balance from Revenue Account	—	—	78 16 9
Opening Valuation:			
Livestock	62 5 0	80 10 0	32 0 0
Hatching Eggs	—	—	12 6 0
Foods and Grit	11 7 6	18 8 0	—
Disinfectants	—	0 8 0	—
Litter	—	4 0 0	—
Capital Depreciation	60 0 0	86 0 0	64 0 0
Net Profit	242 7 9	605 4 6	—
	376 0 3	794 10 4	187 2 9

	Dec., 1928.	*Dec.*, 1932.	*Dec.*, 1935.
	£ s. d.	£ s. d.	£ s. d.
Balance from Revenue Account	272 14 3	633 13 10	—
Closing Valuation:			
Livestock	80 10 0	124 0 0	163 15 0
Hatching Eggs	—	12 10 0	12 0 0
Foods and Grit	18 8 0	16 7 0	9 3 0
Disinfectant	0 8 0	—	—
Litter	4 0 0	5 10 0	—
Paraffin	—	1 19 6	—
Egg and Chick Boxes	—	0 10 0	—
Net Loss	—	—	2 4 9
	376 0 3	794 10 4	187 2 9

years 1933-5. The number of hatching eggs sold in the first three years was only 2,219 but in the last two years the total number was 10,729.

The sale of day-old chicks has been increased and income from this source for the four years 1929-32 amounted to nearly 30 per cent. of total gross income as compared with 8.6 per cent. in the first three years. No chicks were sold in 1933, but sales in the last two years provided 22.8 per cent. of the gross income in 1933-5. In 1926 day-old chicks were sold during the three months March-May, but during recent years there has been an increasing demand for January hatched chicks and last year sales of chicks for 1936 commenced in December.

In the first three years, large quantities of market eggs were preserved in the spring, when prices were low, and sold in the autumn when prices for eggs were at their highest. This practice was not continued after 1928. Income from the sale of preserved eggs in the first three years amounted to about 11.6 per cent. of the total gross income.

No attempt has been made to produce large numbers of stock birds and pullets, and income from table poultry has been incidental to the policy of hatching out chicks for sale or to building up and maintaining the laying flock.

The following table shows the contribution made by each item per £100 net return for each of the three periods.

Income per £100 of Net Returns.

	Three years. 1926-8.	*Four years. 1929-32.*	*Three years. 1933-5.*
	£ s. d.	£ s. d.	£ s. d.
Market eggs	67 18 10	58 0 3	58 14 0
Preserved eggs	11 10 6	—	—
Hatching eggs	2 17 2	6 0 4	9 9 4
Day-old chicks	8 8 4	29 4 8	20 11 2
Table poultry, old hens and young cockerels	7 0 7	2 16 10	5 0 5
Stock birds and pullets	17 7	15 5	19 8
Appreciation on flock	1 5 3	2 9 3	9 14 10
Other receipts	1 9	13 3	10 7
Total	100 0 0	100 0 0	100 0 0

Prices of market eggs have declined more sharply than those for table poultry and young stock. The prices received for hatching eggs was well maintained until 1931, but while an appreciable fall has taken place during the last four years, the price of eggs sold on this market in 1935 was still 1s. 7d. per dozen above the average price received for market eggs.

An interesting feature of the price movements of market eggs for the last ten years is the narrowing of the margin between the price received in November (the peak month) and that obtained in May (one of the months of lowest prices). In 1926 the average price for November was 19s. 3½d. per 120 eggs above that obtained in May of that year, in 1935 the difference was only 11s. 9¼d. This reduction in the difference between the prices received in these two months of any year, is due, largely, to prices in November declining more sharply than those obtained in May. The average price received in November, 1935, was 10s. 7d. per 120 eggs less than for the same month of 1926, while the price obtained in May, 1935, was 3s. 1d. less than in May, 1926.

During the first three years, 1926-8, the average price received for eggs in November fell by about 1s. 1d. per 120 eggs but over the next four years it declined by 8s. 5d. The decline in the price obtained in November continued until 1933, but for the last two years the price of eggs in this month has been higher. The price received in May of each year showed the same general tendencies, that is the fall was greatest during 1929-33. The average annual price received was fairly constant for the three years 1926-8, but fell from 16s. 11d. to 12s. 5d. per 120 during the next four years, and for the last three years the yearly average price has been steadier at the lower level.

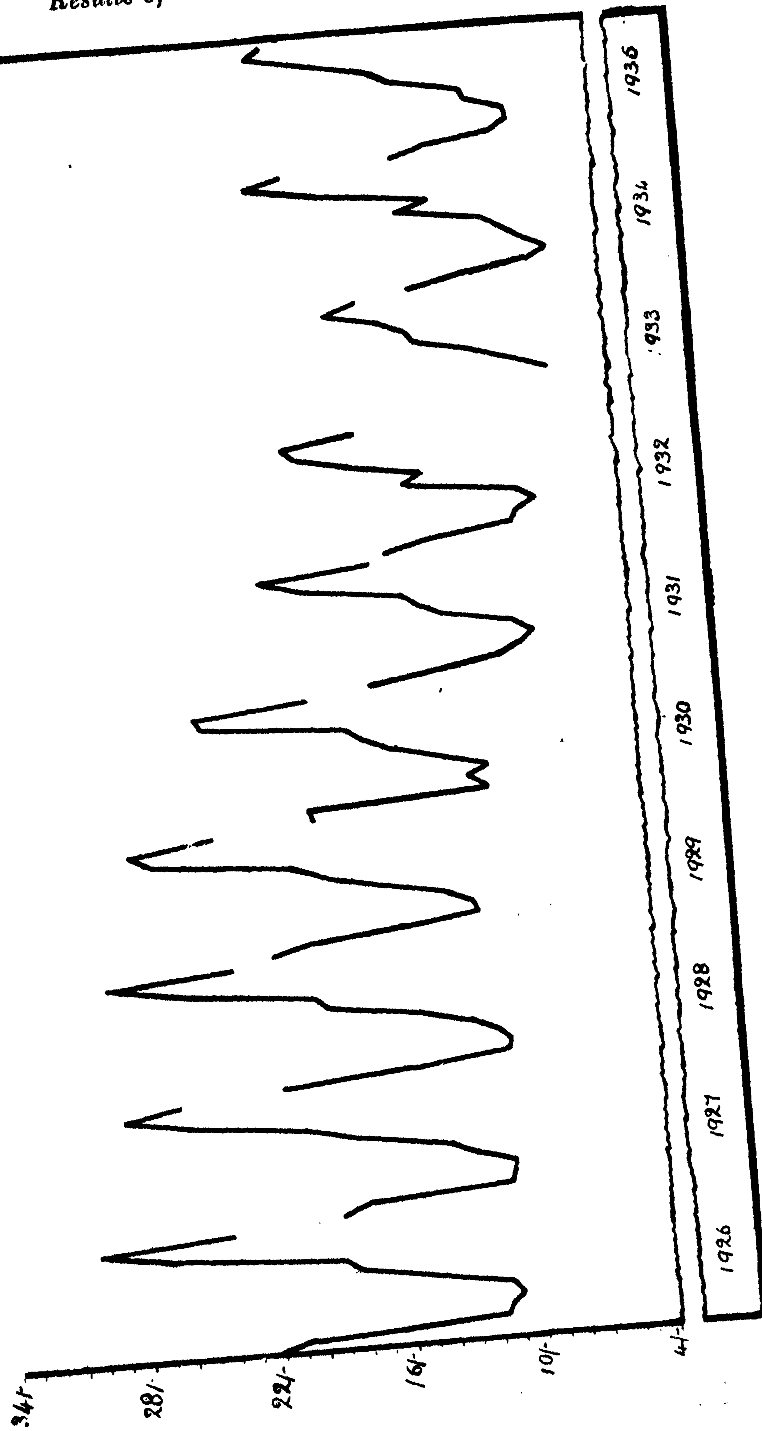
The price received for hatching eggs was, with the exception of 1927, fairly steady at about 4s. 6d. per dozen for the first six years. In 1932 the average price was about 1s. per dozen less than in the previous year. During the last two years the decline continued and the average price per dozen in 1935 was 2s. 9½d. or 7½d. less than in 1932. The average price received in each of the three periods was as follows :—

Period.	*Hatching Eggs. Price per dozen.* *s.*	*d.*
1926-8	4	5½
1929-32	4	3¼
1933-5	2	10½

The average price received for day-old chicks in 1927, like that for hatching eggs, was lower than that of the preceding year or the three following years. The highest price was obtained in 1926, when it averaged 10s. 2d. per dozen. Since 1929 the price has declined sharply, and in 1935 it was over 2s. per dozen less than in 1929.

The gross expenditure, including family labour, amounted to £1,153 19s. 3d. for the first three years, to £1,582 14s. 5d. in the

CHART 1.
Monthly Average Prices of Market Eggs.



next four years, and to £1,229 12s. 3d. in the last three years. There was, therefore, a gross profit of £272 14s. 8d. in the first three years, £688 18s. 10d. in the next four years, and a gross loss of £78 16s. 9d. in the last three years. As the financial records contained no statement of capital invested in poultry houses and equipment, it has been necessary to make an estimated charge for depreciation. When this charge for depreciation, and the changes in the opening and closing valuations of poultry and stores are taken into account the net profit for 1926-8 was £242 7s. 9d., or an average of nearly £81 a year. The net profit for the next four years, 1929-32, was £605 4s. 4d., or £151 a year. During the last three years the accounts showed a net loss of £2 4s. 9d., and the owner's earnings were limited approximately to wages for labour entered as expenses.

Feeding-stuffs was the most important item of expenditure and ranged between 40 and 60 per cent. of the total net costs. In 1926 foods represented about 56 per cent. of the total net costs and increased to over 58 per cent. in the following year. From 1927 to 1931 this item of expenditure declined from 58.5 per cent. to about 40 per cent. of total net costs. Since 1931 foodstuffs have formed a larger part of total net costs and in 1934 amounted to nearly 58 per cent.

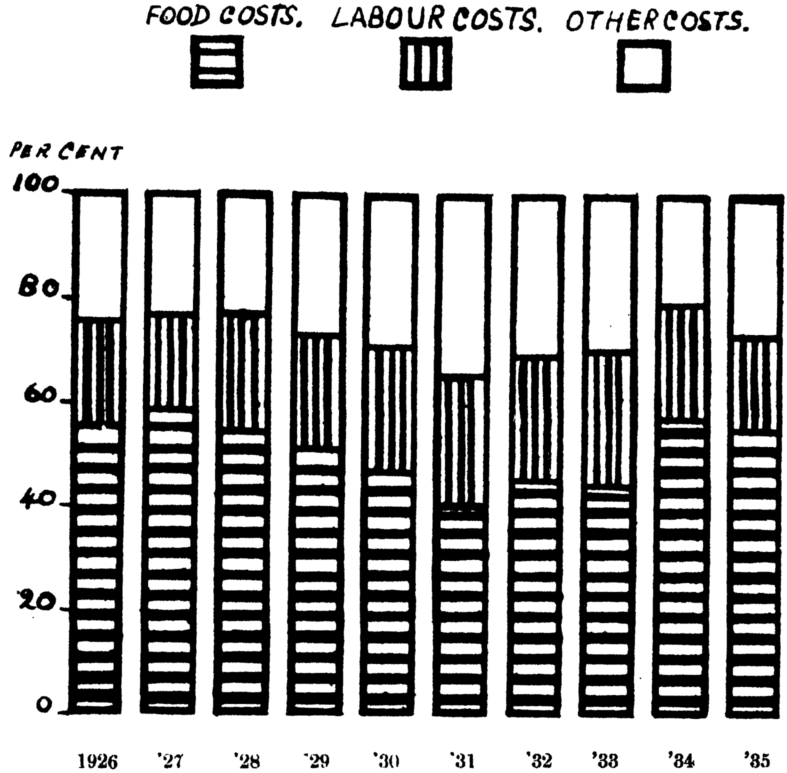
The cost of labour, which ranks second in importance, has shown little variation over the period covered by these accounts. In 1927 and 1935 this item amounted to about 18.7 per cent. of the total net costs and for the other years it has varied from 20 to 26 per cent.

Other costs, which include rent, depreciation on houses and equipment, rearing, and marketing expenses, have varied from about 21 per cent. in 1934 to just over 34 per cent. in 1931, the year in which foods represented only 40 per cent. of the total costs. Chart 2 shows the importance of the three main groups of costs items for each of the ten years.

Items of costs other than those for foods have shown little variation in price during the ten years and their importance as a part of the total costs has therefore changed with movements in prices of foods. The average price paid for foods in the three years 1926-8, was about 11s. 3d. per cwt. Between 1928 and 1931 the average price declined from 12s. 0d. to 7s. 0d. per cwt. The average price per cwt. for the next two years increased by more than 1s. per cwt. and the average price paid in 1935 was 7s. 5d., the lowest since 1931.

CHART 2.

Distribution of Net Costs.



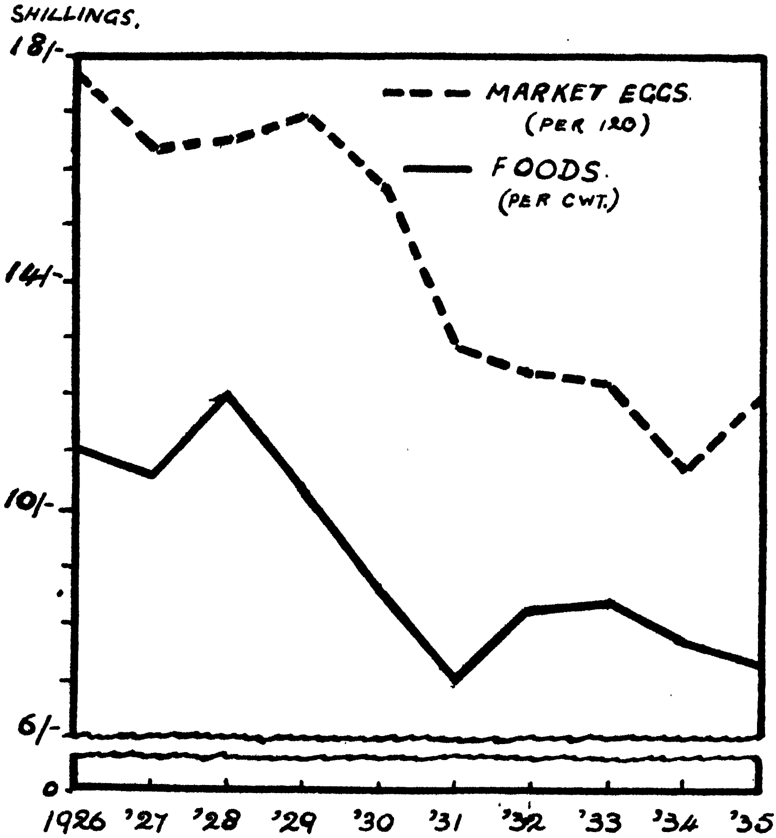
In view of the importance of the relationship between prices of foods and eggs Chart 3 is of interest.

From 1926 to 1928 the margin between the average amount received for 120 market eggs and the amount paid for one cwt. of food narrowed from 7s. 2d. to 4s. 6d. In the next two years the average price of eggs declined less rapidly than that of feeding-stuffs and the margin became wider. In 1930 the margin was about the same as in 1926. In 1931 the average price received for 120 market eggs fell by 2s. 11d. and the price of foods by 1s. 6d. per cwt. During 1932 and 1933 the decline in the average price of eggs was only very small but the price of foods improved from 7s. to 8s. 4d. per cwt. and the margin between these two prices was reduced to 3s. 10d. The average price received for market eggs in 1934 was 1s. 6d. per 120 eggs lower than in 1933 and the price of foods fell by 8d. per cwt. and the margin was further reduced to 3s. Last year the average price received for

market eggs improved while the price of foods showed a fall of 8d. per cwt. and the margin was the widest since 1931.

CHART 3.

Annual Average Price of Eggs and Feeding Stuffs.

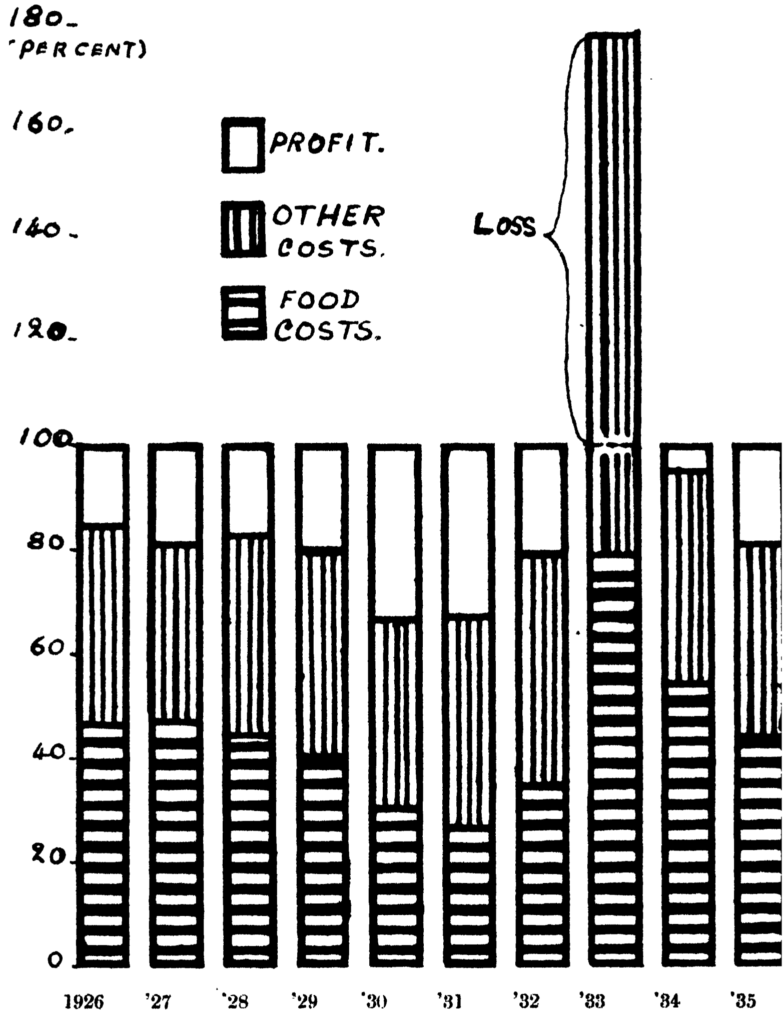


Evidence that reductions in the costs of foods was mainly responsible for the increasing profitability of the enterprise before 1932 is seen in Chart 4.

Apart from the year when additional costs were incurred in building up the laying flock, all costs other than those for foods have represented about the same proportion of total net receipts. As the cost of foods declined in importance the profitability of the enterprise increased. In 1926 foods represented 56 per cent. of net expenditure and 47 per cent. of net income, and in 1931 40 per cent. of net expenditure and 27 per cent. of net income. Last year the relative figures were 55 per cent. of net expenditure and 44 per cent. of net income.

CHART 4.

Costs and Profits as a Percentage of Net Returns.



During the first three years the input for every £100 of output was £83 4s. 6d., thus leaving a net profit of £16 15s. 6d. on each £100 of output. Owing to the fall in the price of feeding-stuffs during the next four years the input per £100 of net output was reduced to £73 7s. 4d., leaving a profit margin of £26 12s. 8d. per £100 of output. In 1933 sales were reduced to a minimum owing to the change of farms and the building up of a new laying flock and as a result the input per £100 of net output for the three years 1933-5 was increased to £100 8s. 4d., making a net

loss of 8s. 4d. per £100 output. The Table also shows the importance of each item of cost per £100 of net returns.

Net Costs per £100 of Net Returns.

	Three years. 1926-8.	*Four years. 1929-33.*	*Three years. 1933-5*
	£ s. d.	£ s. d.	£ s. d.
Foodstuffs	46 18 11	33 18 2	53 5 9
Labour, including family labour	17 6 0	17 12 1	21 8 10
Horse labour	5 3 10	4 8 0	—
Marketing expenses	1 14 10	2 19 6	2 16 11
New stock and hatching eggs	15 9	1 12 11	5 15 9
Vet., blood testing and disinfectant	18 10	1 2 10	2 9 9
Paraffin	1 6 8	2 12 5	3 12 6
Litter	1 15 1	1 16 3	1 11 5
Rent and Rates	1 2 3	18 10	2 10 3
Preserving expenses	10 1	—	—
Repairs and sundries	1 9 2	2 10 8	1 17 6
Depreciation on equipment	4 3 1	3 15 8	4 14 8
Total net costs	83 4 6	78 7 4	100 3 4

The annual net profit increased from £65 18s. 2d. in 1926 to £201 10s. 0d. in 1930. Since 1930 the profitability of the industry has declined and in 1932 the net profit was £106 7s. 6d. Owing to the changes which took place in 1933 a net loss of £152 7s. 4d. was sustained but in the next year a small profit was obtained. Last year conditions improved considerably and a net profit of £124 17s. 7d. was secured. The net receipts, costs and profit for each of the ten years were as follows :—

Net Receipts, Expenses and Profits.

Year.	*Net Receipts.*	*Net Expenses.*	*Net Profit.*
	£ s. d.	£ s. d.	£ s. d.
1926	486 10 10	370 17 8	65 18 2
1927	491 7 2	401 10 3	89 16 11
1928	519 6 7	432 8 11	86 17 8
1929	569 5 1	455 1 10	114 3 3
1930	611 7 10	409 17 10	201 10 0
1931	574 2 4	390 18 9	183 3 7
1932	519 0 6	412 13 0	106 7 6
1933	194 15 2	347 2 6	*152 7 4* *
1934	496 6 0	472 1 10	25 5 0
1935	660 9 4	535 11 9	124 17 7
Total	5,078 10 10	4,228 3 6	845 7 4
Average (per year)	507 7 1	422 16 4	84 10 9

* Net loss.

Taking the average for the ten years the net profit was £84 10s. 9d., which would be equivalent to a return of over 20 per cent. on the average annual capital investment.

From the point of view of the farmer the most important consideration is the size of the income derived from the enterprise after all current expenses have been met and when depletions of the capital invested have been made good. In this case a portion of the net profit has been re-invested in the enterprise, but the net profit, together with the charge made for family labour, is the farmer's total income derived from the enterprise and is the amount which the farmer could have withdrawn for personal use without depleting the capital invested. This sum amounted to £1,615 7s. 4d. for the ten years—an average income of £161 10s. 10d. per year. Approximately one-half of this sum has been attributed to the manual labour of the operator, and the other half represents the earnings of management and of capital.

MEAT CONSUMPTION IN THE RHONDDA VALLEY.

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University College, Aberystwyth.

The general, social and economic features of the area in which this study was made were described in this Journal last year, and as conditions remain substantially the same there is no need for a repetition of that description.[1]

Records were collected of household constitution with particulars of consumption of butchers' meat, cured meat, prepared and tinned meat, fish and eggs, as well as particulars of sources and size of incomes, and almost all householders from whom records were obtained gave similar information on milk consumption last year. The facts presented in this study were collected directly by a team from this department for the week May 27th—June 2nd, 1935.* Record sheets were left in households at the end of one week and collected at the end of the next. The response was quite satisfactory and 259 households provided records covering 899 adults, 201 children from seven to fourteen years and 187 below seven years. Children have been converted into adult equivalents on the basis indicated below, and no

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* Department of Agricultural Economics.

1 *Welsh Journal of Agriculture*, Vol. XI, page 28.

distinction is made between males and females throughout the figures presented in the study.[2]

Householders providing records expressed the opinion that the consumption of butchers' meat, prepared meat, bacon and ham was well below the highest seasonal points and was still falling; consumption of eggs, however, was at about its highest seasonal point, and that of fish about normal. There were no abnormal features present during the enquiry tending to upset the normal course and intensity of consumption. Volume of employment was normal; weather conditions were perhaps a little colder and wetter than is customary for the time of year. There were no abnormal cases of illness, and few people normally resident in the district were away on holidays or business.

In parts of the Rhondda Valley butchers' meat and fish, as well as some other foods not included in the present study, were sold by auction as well as in shops. These auctions were held sometimes once, sometimes twice weekly in different parts on different days, and a large number of consumers had easy access to this method of purchasing. The facilities for purchasing offered and the quality of the goods sold in this way varied rather widely from time to time and from place to place. But large households with small means, in particular, welcomed this method of obtaining their food requirements. It appears that the "auction method" of selling food requirements has taken firm hold and many influential business people forecast an extension of it in the distressed areas of South Wales.

Not all the eggs and meat consumed were purchased from shops and auctions. Many householders kept poultry—mainly hens, and a number kept pigs. Owing to this many households produced all the eggs they needed and a quantity of the fresh meat. Surplus eggs and meat were sold by retail to neighbours. In all cases where householders consumed home-produced products accurate records were kept of domestic consumption and sales. For the purposes of this study both meat and eggs raised by householders and consumed by them have been evaluated at market prices ruling in the district.

The nature and constitution of households by income groups is shown in Table I.[3] The majority of households and persons

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[2] One adult equals two children from seven to fourteen years.
One adult equals four children under seven years.

[3] Group 1 Income per person up to 7/5.
Group 2 Income per person 7/6—12/5.
Group 3 Income per person 12/6—17/5.
Group 4 Income per person 17/6—22/5.
Group 5 Income per person 22/6—27/5.
Group 6 Income per person 27/6—32/5.
Group 7 Income per person over 32/5.

fall into the first four groups, the numbers in the last three being small. This is almost inevitable, for income per person depends on total income and the number of persons per household. The tendency for the number of adults, children from seven to fourteen years, and children below seven years per household to decrease as income increases is quite clear. When total persons per household are considered this tendency is even strengthened, for there is an unbroken fall in the number of persons per household from the lowest to the highest income group—a fall from 6.70 to 2.44 persons per household. The average constitution per household shows a very close agreement with that obtained in the survey of milk consumption.[4] As this study was conducted in the same area and as far as possible over the same households, it appears that it is fully representative. It is true that the number of households is smaller than that covered in the milk consumption study, but as the number of commodities entering into this study is comparatively large and varied no greater number could be surveyed with available resources.

TABLE I.

Household Constitution by Income Groups.

GROUP.	1	2	3	4	5	6	7	*Whole Group*
No. of Households	50	103	61	21	7	8	9	259
Adults (Total)	198	376	206	61	17	21	20	899
Adults per Household	3.96	3.65	3.37	2.90	2.43	2.63	2.22	3.47
Children from 7 to 14 years (Total)	78	85	26	6	4	2	0	201
,, ,, ,, per Household	1.56	0.82	0.43	0.29	0.57	0.25	0	0.78
Children under 7 years (Total)	59	47	18	9	1	1	2	137
,, ,, ,, per Household	1.18	0.46	0.29	0.43	0.14	0.12	0.22	0.53
Total Persons	335	508	250	76	22	24	22	1237
,, ,, per Household	6.70	4.93	4.09	3.62	3.14	3.00	2.44	4.78

Information was sought and obtained on amounts of household incomes derived from salaries and wages, unemployment insurance, public assistance and pensions. Income from private sources and from the profits of poultry keeping and the raising of pigs were almost negligible and have been ignored. The proportion of income derived from each source for each income group is shown in Table II. Over the 259 households total income was derived approximately as follows: Six-tenths wages or salaries; three-tenths unemployment insurance, and one-tenth public assistance and pensions. Of more interest and use, however, is the proportion of income derived from each source in each income group. Salaries and wages showed a rise from under 20 per cent. of total income in Group 1 to 100 per cent. in

[4] *Welsh Journal of Agriculture*, Vol. XI, page 25.

Group 5. Unemployment insurance was an important part—almost 70 per cent.—of total income, particularly in the lower

TABLE II.

SOURCES OF INCOME.

Households grouped according to Income per Person.

Group.	*Number of Persons.*	*Salaries or Wages.*	*Unemployment Insurance.*	*Public Assistance.*	*Pensions.*	*Total.*
		%	%	%	%	%
1	335	19.59	69.65	8.88	1.88	100.00
2	508	49.56	36.60	5.68	8.16	100.00
3	250	70.38	22.95	2.90	3.77	100.00
4	76	83.42	9.41	1.63	5.54	100.00
5	22	100.00	—	—	—	100.00
6	24	87.33	4.03	—	8.64	100.00
7	22	96.88	3.12	—	—	100.00
Whole Group	1,237	60.74	29.99	4.17	5.10	100.00

income groups, but as income per person increased there was a rapid decrease in income derived from this source. A much lower proportion of income was derived from public assistance, and it appeared only in the four lower income groups. It falls from nearly 9 per cent. of total income in Group 1 to well under 2 per cent. in Group 4. There is no clear relationship between income per person and the proportion of total income derived from pensions. The average figures for the whole group again agree very closely with those collected in the milk consumption survey.[5]

Some Explanations.

The expression "meatstuffs," as used in this study, comprises: butchers' meat, edible offals and prepared meat; cured meat; canned and other prepared meat; fish (including fish bought from fish and chip shops); and eggs. The object of using this expression is to show the relationship between income per person and the consumption of these foods as a whole on the basis of weight and value. In this way a clearer and more definite relationship is established between income and expenditure on, and consumption of, foods which are in certain circumstances, highly competitive, and in others complementary in the dietary of the people of the area.

Information relating to weights of purchases of all meats is approximate. Few householders knew definitely the weights of meats purchased, and it appears that they seldom asked sellers for these weights. In fact it was customary for purchasers

[5] *Welsh Journal of Agriculture*, Vol. XI, page 25.

to ask for so many 6d. chops or a joint worth say 4s. to 4s. 6d. But as total prices paid and the type and cost per unit weight of each separate purchase of butchers' meat was known the total weight was calculated. While great care was taken to arrive at the correct weight of meat purchased, it must be realised that there may be a slight over-statement or under-statement of weights in the figures. Some of the edible meat offals were sold at so much each and not by weight, and here again weights have been interpolated. No uniform scale of doing this was possible as the type of offal purchased varied enormously in size and kind. Fish again presented the same difficulty, and all fish consumed has been converted to a weight basis, but not on any uniform scale. In this case a further complication arose because records of fish bought from fish and chip shops as well as records of fish bought in the ordinary way had to be obtained and these again had to be converted to a weight basis. Numbers of eggs bought and consumed were known with exactitude, and they have been converted to a weight basis by multiplying by a constant factor.[6] It must be realised that the limitations enumerated relating to the weight of " meatstuffs " bought and consumed apply to all the tables that follow, and any unqualified reference to numerical data relating to weights is subject to such limitations. But householders knew exactly what sums of money were spent on " meatstuffs," and their statements of expenditure are precise.

Relationship of income per person and consumption of " meatstuffs " per household, per person and per adult equivalent.

The values and quantities of meatstuffs by income groups relating to households, persons and adult equivalents are shown

TABLE III.

Consumption and Cost of " Meatstuffs " per Household, per Person and per Adult Equivalent.

Particulars.	*Group* 1	*Group* 2	*Group* 3	*Group* 4	*Group* 5	*Group* 6	*Group* 7	*Whole Group*
Number of Households	50	103	61	21	7	8	9	259
Persons per Household	6.70	4.93	4.09	3.62	3.14	3.00	2.44	4.78
Adult Equivalents per Household	5.03	4.18	3.66	3.15	2.75	2.78	2.28	3.99
Weight of Total Meatstuffs (lbs.).								
Per Household	10.30	9.83	10.90	11.38	10.64	10.23	10.12	10.42
Per Person	1.52	1.99	2.75	3.06	3.39	3.40	3.49	2.16
Per Adult Equivalent	2.04	2.36	2.97	3.61	3.86	3.68	4.44	2.59
Value of Total Meatstuffs (Pence).								
Per Household	104.66	113.84	126.67	139.79	128.86	139.80	137.33	119.60
Per Person	15.62	23.08	31.05	38.60	41.03	46.59	56.28	25.02
Per Adult Equivalent	20.80	27.22	34.60	44.37	46.85	50.27	60.23	29.98

in Table III. The data for households is useful for information and further analysis, and it is for this reason that it is presented here.

[6] One dozen equals 22 ozs.

The relationship between income per person and consumption and cost of " meatstuffs " per household shows no well defined trend, but the relationship is far more striking on the per person basis, while that on an adult equivalent basis shows the best relationship. It is for this reason that the latter expression is adopted here as the most desirable basis of discussion of results.

TABLE IV.

Consumption and Cost of " Meatstuffs " per Adult Equivalent.

Group.	*Weight of Purchases.*	*Value of Purchases.*	*Value per lb.*
	lbs.	*d.*	*d.*
1	2.04	20.80	10.25
2	2.36	27.22	11.53
3	2.97	34.60	11.65
4	3.61	44.37	12.29
5	3.86	46.85	12.14
6	3.68	50.27	13.66
7	4.44	60.23	13.57
Whole Group ..	2.59	29.98	11.57

Table IV shows the relationship of the consumption of all " meatstuffs " and income per person. There is a fairly regular increase in the total weight of " meatstuffs " purchased from the lowest to the highest income group. This increase is fairly regular and continuous up to Group 6, where a small decline in the total weight of " meatstuffs " consumed is indicated. Another increase however, is recorded in Group 7 to the highest point in the weight series. Values of meatstuffs purchased show a continuous but irregular increase from the lowest to the highest income group. In the lowest income group about 1s. 9d. per " adult " is spent on " meatstuffs " and about 5s. in the highest, with the average about 2s. 6d. coming between income Groups 2 and 3. The value of " meatstuffs " per unit weight also shows a clear tendency to increase with increase in income. Prices per lb. rise from about 10¼d. to over 1s. 1½d. There is a tendency for the figures in the series to go in pairs after passing Group 1. The figures in Groups 2 and 3, 4 and 5, 6 and 7 " pair off." The general average figures for total weights, total values and values per lb. fall between those of Groups 2 and 3.

It appears that not only is there a tendency for the weight of " meatstuffs " bought to increase with increase in income, but the quality of " meatstuffs " bought also improves. This is shown by the fact that there is an increase in the price per unit weight paid for " meatstuffs " from the lower to the higher income groups which is particularly noticeable when income groups are " paired off " as already indicated. Some of the increase in the price per

unit weight of " meatstuffs " may be due to distributors charging more for similar quality stuff to consumers in the higher income groups. But even if part of the increase in prices paid can be attributed to this cause, the remainder, which is the greater part, must be due to a real capacity of consumers in the higher income groups to demand and pay for better " meatstuffs " and distributive services associated with them.

Types of " meatstuffs " consumed.

Variations in weights and values of each type of "meatstuff" show a relation but not a regular relation to income. Proportional weights and values of fresh meat and cured meat tend to increase with income and those for prepared and tinned meat tend to fall, while those for eggs and fish show little change in relation to income. Table V illustrates the fact that types of " meatstuffs " and income are less closely related than total consumption of " meatstuffs " and income. Yet, in general, there is an indication that more of the dearest types of " meatstuffs " are consumed by the households with the higher incomes. On an average untreated butchers' meat accounts by weight for 48 per cent. of total consumption, cured meat for 13 per cent., prepared and tinned meat 11 per cent., fish 13 per cent., and eggs 19 per cent; the proportions by value are untreated butchers' meat 48 per cent., cured meat 17 per cent., prepared and tinned meat 10 per cent., fish 9 per cent., and eggs 16 per cent.

TABLE V.

Percentage Distribution of Types of " Meatstuffs " by weight and value by income groups. (Total weight and value, each = 100).

	Group 1	*Group 2*	*Group 3*	*Group 4*	*Group 5*	*Group 6*	*Group 7*	*Whole Group.*
Untreated Butchers' Meat.								
Quantity	38.5	41.1	42.3	46.2	44.0	45.9	39.8	42.6
Cost	42.7	45.0	45.6	51 0	54.1	53.0	45.0	48.3
Cured Meat.								
Quantity	13.8	13.0	15.6	10.4	9.4	17.0	13.8	13.3
Cost	17.8	16.7	20.3	13.4	12.0	18.3	17.7	16.6
Prepared—Tinned.								
Quantity	16.5	13.6	11.5	11.7	9.8	8.5	9.3	11.5
Cost	12.7	11.8	9.3	10.6	7.6	8.4	11.2	10.1
Fish.								
Quantity	13.3	12.0	11.4	12.7	17.5	11.0	13.7	13.1
Cost	9.4	9.2	8.5	9.3	10.0	6.7	8.8	8.8
Eggs.								
Quantity	17.9	20.3	19.2	19.0	19.3	17.6	23.4	19.5
Cost	17.4	17.3	16.3	15.7	16.3	13.6	17.3	16.2

The consumption of all meat and fish shows almost continuous increases from the lowest to the highest income group (Table VI). Expenditure also follows a similar course and shows an unbroken sequence of increases. Values per unit weight also show an

unmistakeable trend to increase with increases in income, but these are not regular. No doubt one of the most important factors causing this irregularity is the existence of forces affecting consumption apart from income.

Table VII shows the relation between income and the consumption, the expenditure and the prices per unit weight of untreated butchers' meat, excluding fish. Weights of meat purchased show an increase which is fairly wide from group to group up to Group 4. There is a negligible fall in the next group followed by comparatively narrow rises. The tendency for purchases to increase with income, however, is significant, and Group 7 consumed twice as much as Group 1. Expenditure shows an unbroken sequence of increases from group to group, households in Group 7 spending about three times as much as those in Group 1. The values per unit weight again show an increase from the lowest to the highest group. But as consumption in Group 7 is twice that in Group 1 and expenditure three times as much the latter increase is partly one of increased consumption, partly one of increase in quality purchased, and partly payment for provision of better distributive services.

TABLE VI.

Consumption and Cost of all Meat and Fish per adult equivalent by income groups.

Group.	*Weight of Purchases.*	*Value of Purchases.*	*Value per lb.*
	lbs.	*Pence.*	*Pence.*
1	1.67	17.19	10.29
2	1.88	22.53	11.98
3	2.40	28.96	12.07
4	2.92	37.39	13.15
5	3.11	39.22	12.61
6	3.03	43.44	14.34
7	3.40	49.80	14.65
Whole Group ..	2.09	24.98	11.95

TABLE VII.

Consumption and Cost of all Meat (excluding fish) per adult equivalent by income groups.

Group.	*Weight of Purchases.*	*Value of Purchases.*	*Value per lb.*
	lbs.	*Pence.*	*Pence.*
1	1.40	15.24	10.88
2	1.60	20.01	12.51
3	2.06	26.03	12.64
4	2.46	33.25	13.52
5	2.44	34.52	14.15
6	2.63	40.07	15.24
7	2.79	44.49	15.95
Whole Group ..	1.77	22.28	12.59

Consumption and cost of untreated butchers' meat shows a close relation to incomes (Table VIII). Quantities show increases from the lower groups to the higher ones broken by a negligible fall in Group 6, which is followed by a rise in Group 7. The highest income group shows a two-fold increase in consumption as compared with the lowest income group. Values of purchases show an unbroken sequence of increases from the lower to higher income groups and Group 7 spent three times as much as Group 1. Unit values also rise with increases in income with the exception of Group 7.

TABLE VIII.

Consumption and Cost of Untreated Butchers' Meat per adult equivalent by income groups.

Group.	*Weight of Purchases.*	*Value of Purchases.*	*Value per lb.*
	lbs.	*Pence.*	*Pence.*
1	0.79	8.89	11.25
2	0.97	12.26	12.64
3	1.26	15.78	12.52
4	1.67	22.62	13.54
5	1.70	25.35	14.91
6	1.69	26.66	15.71
7	1.77	27.12	15.32
Whole Group ..	1.08	13.73	12.71

Table IX shows the relation between income and type of untreated butcher's meat purchased. Beef accounts for approximately 70 per cent. of the total weight and value in Group 1, falling to 30 per cent. in Group 7 though the fall from the lower to the higher income groups is not regular. Mutton and lamb show quite opposite tendencies and percentage consumption and value rise from around 20 per cent. of the total in Group 1 to about 50 per cent. in Group 7. In comparison, consumption of pork shows no definite relation to income and in general the proportion consumed is low. This may have something to do with the time of year this study was made (May, June and July are close seasons for pork in the estimation of many households); again proportions for veal are low, while those for poultry and game are still lower. Trade in the latter is highly seasonal and concentrated around Christmas time. No edible offals were consumed by Group 1, being due to this group recording heavy purchases of "bits," and there is no definite indication of a proportional relation to income owing to the variable nature of

TABLE IX.

Percentage distribution of purchases of untreated butchers' meat in income groups by weight and value.

Group.	*Beef.*	*Mutton and Lamb.*	*Pork.*	*Veal.*	*Poultry. and Game.*	*Edible Offals.*	*Total.*
1. Weight .	70.8	22.3	6.2	0.7	—	—	100
Value ..	70.2	21.5	7.5	0.8	—	—	100
2. Weight .	55.7	29.7	4.9	0.4	—	9.3	100
Value ..	54.9	30.7	5.9	0.6	—	7.9	100
3. Weight .	46.5	24.8	9.5	4.9	2.3	12.0	100
Value ..	45.9	25.9	10.6	5.3	2.7	9.6	100
4. Weight .	51.4	33.5	4.7	—	2.7	7.7	100
Value ..	51.0	34.1	6.2	—	3.2	6.5	100
5. Weight .	50.4	27.5	—	—	—	22.1	100
Value ..	53.5	30.1	—	—	—	16.4	100
6. Weight .	42.7	42.7	2.6	2.6	—	9.4	100
Value ..	42.5	45.1	2.8	2.7	—	6.9	100
7. Weight .	32.4	47.6	5.5	—	7.6	6.9	100
Value ..	30.5	50.5	5.7	—	7.5	5.8	100
Whole Group							
Weight .	53.6	28.7	6.1	1.6	1.1	8.9	100
Value ..	52.5	30.1	6.9	1.8	1.4	7.8	100

offals and their prices. On an average half the untreated butchers' meat consumed was beef, a third was mutton and lamb, and the rest was a miscellaneous variety.

The consumption and cost of cured meat is shown in Table X. Increases are shown up to income Group 4 where a fall occurs, the same intensity of consumption is maintained in the next group, then a significant increase occurs followed by a slight fall. There is a two-fold increase in consumption from the lowest to the highest income group. Values increase from Group 1 to Group 4, where a fall occurs, followed by another small fall and then rises are recorded to the end of the value series. Three times as much is spent on cured meat in the highest as compared with the lowest income group. Values per unit weight show increases up to Group 5 where a fall occurs, and then another fall in Group 6, followed by a rise in the last Group. There is a less definite relation between consumption, value of purchases, and values per unit weight of cured meat and income than for untreated butchers' meat.

Table XI shows that on an average about 80 per cent. by weight and 76 per cent. by value of cured meat is bacon and about 20 per cent. by weight and 24 per cent. by value is ham. In general there is a tendency for the proportion of bacon consumption and values to be highest in the lower income groups with the notable exception of Groups 5 and 6, while the data for ham show the opposite tendency,Groups 5 and 6 again being exceptions.

TABLE X.

Consumption and Cost of Cured Meat per Adult Equivalent by income groups.

Group.	*Weight of Purchases.*	*Value of Purchases.*	*Value per lb.*
	lbs.	*Pence.*	*Pence.*
1	0.28	3.71	13.25
2	0.31	4.54	14.64
3	0.46	7.04	15.30
4	0.37	5.95	16.08
5	0.36	5.61	15.58
6	0.63	9.21	14.62
7	0.61	10.62	17.41
Whole Group ..	0.35	5.22	14.91

TABLE XI.

Percentage Distribution of Bacon and Ham in income groups by weight and value.

Group.		*Bacon.*	*Ham.*	*Total.*
1.	Weight	87.4	12.6	100
	Value	83.6	16.4	100
2.	Weight	82.3	17.7	100
	Value	80.0	20.0	100
3.	Weight	75.2	24.8	100
	Value	71.3	28.7	100
4.	Weight	72.7	27.3	100
	Value	70.5	29.5	100
5.	Weight	78.6	21.4	100
	Value	74.1	25.9	100
6.	Weight	85.7	14.3	100
	Value	84.4	15.6	100
7.	Weight	56.0	44.0	100
	Value	52.3	47.7	100
Whole Group.	Weight	79.8	20.2	100
	Value	76.3	23.7	100

The consumption of prepared and tinned meats shows relatively little change with increase in incomes and the range between the highest and lowest income group is a narrow one.

(Table XII). Values of purchases, however, show a tendency to rise with increases in income but the tendency is irregular and broken. But the range of values from the highest to lowest income group is significantly wide. Values per unit weight show no uniform trend and vary from group to group without any clear relation to income. Table XIII shows that over all groups nearly 80 per cent. by weight and 76 per cent. by value of prepared and tinned meat consumed is prepared meat and 20 per cent. by weight and 24 per cent. by value is tinned meat. No clear relationship is established between income and the relative proportions of prepared and tinned meat consumed.

TABLE XII.

Consumption and Cost of Prepared and Tinned Meat per Adult Equivalent by income groups.

Group.	*Weight of Purchases.*	*Value of Purchases.*	*Value per lb.*
	lb.	*Pence.*	*Pence.*
1	0.33	2.64	8.00
2	0.32	3.21	10.03
3	0.34	3.21	9.44
4	0.42	4.68	11.14
5	0.34	3.56	9.36
6	0.31	4.20	13.54
7	0.41	6.75	16.46
Whole Group ..	0.34	3.33	9.79

TABLE XIII.

Percentage distribution of prepared and tinned meat in income groups by weight and value.

Group.		*Prepared Meat.*	*Tinned Meat.*	*Total.*
1.	Weight	84.7	15.3	100
	Value	79.6	20.4	100
2.	Weight	76.0	24.0	100
	Value	73.8	26.2	100
3.	Weight	81.3	18.7	100
	Value	78.5	21.5	100
4.	Weight	66.1	33.9	100
	Value	60.3	39.7	100
5.	Weight	89.7	10.3	100
	Value	89.1	10.9	100
6.	Weight	100.0	—	100
	Value	100.0	—	100
7.	Weight	79.4	20.6	100
	Value	75.1	24.9	100
Whole Group.	Weight	79.3	20.7	100
	Value	75.8	24.2	100

The relationship between income and consumption of fish is shown in Table XIV.

Increases are recorded up to Group 6, where a fall occurs, and though an increase is recorded in Group 7, it is still below the figure for Group 5. Consumption is two and a half times as great in the highest as compared with the lowest income group and values follow the same course, Group 5 being highest, followed by Group 7. Values per unit weight show no clear relationship to income per person. Purchases of fish show a little more relationship to income than commodities like cured meat, prepared and tinned meat. No distinction has been made in the types of fish purchased. The proportion of consumption of fish to total meatstuffs by income groups is shown in Table XV. The average consumption of fish by weight and value is 18 per cent. and 9 per cent. respectively of total consumption of "meatstuffs."

TABLE XIV.

Consumption and Cost of Fish per Adult Equivalent by income groups.

Group.	*Weight of Purchases.*	*Value of Purchases.*	*Value per lb.*
	lb.	*Pence.*	*Pence.*
1	0.27	1.95	7.22
2	0.28	2.52	9.00
3	0.34	2.93	8.61
4	0.46	4.14	9.00
5	0.67	4.70	7.01
6	0.40	3.37	8.42
7	0.61	5.31	8.70
Whole Group ..	0.32	2.70	8.43

TABLE XV.

Percentage distribution of Fish and other meatstuffs in income groups by weight and value.

Group.		*Fish.*	*Other Meatstuffs.*	*Total.*
1.	Weight	13.3	86.7	100
	Value	9.4	90.6	100
2.	Weight	12.0	88.0	100
	Value	9.2	90.8	100
3.	Weight	11.4	88.6	100
	Value	8.5	91.5	100
4	Weight	12.7	87.3	100
	Value	9.3	90.7	100
5.	Weight	17.5	82.5	100
	Value	10.0	90.0	100
6.	Weight	11.0	89.0	100
	Value	6.7	93.3	100
7	Weight	13.7	86.3	100
	Value	8.8	91.2	100
Whole.	Weight	13.1	86.9	100
Group	Value	8 8	91.2	100

The consumption of eggs averaged ½lb. per adult equivalent, and there is a threefold increase by weight in the highest as compared with the lowest income group (Table XVI). Aggregate values of purchases with one exception show increases with rises in income, and the group showing highest value of purchases has three times that showing the least. Values per unit weight of purchases show very small regular increases, but the range, from 10d. to 10½d., is surprisingly narrow. The relation between income and consumption of eggs is a much closer one than that between income and the consumption of cured meat, prepared and tinned meats or fish.

The relative proportions of consumption by weight and value of eggs as compared with " meatstuffs " is shown in Table XVII, and again no statement is given of the relative proportions of different varieties of eggs entering into total egg consumption.

TABLE XVI.

Consumption and Cost of Eggs per Adult Equivalent by income groups.

Group.	*Weight of Purchases.*	*Value of Purchases.*	*Value per lb.*
	lb.	*Pence.*	*Pence.*
1	0.37	3.61	9.75
2	0.48	4.69	9.77
3	0.57	5.64	9.89
4	0.69	6.98	10.11
5	0.75	7.63	10.17
6	0.65	6.83	10.50
7	1.04	10.43	10.02
Whole Group ..	0.50	5.00	10.00

TABLE XVII.

Percentage distribution of Eggs and other meatstuffs in income groups by value and weight.

Group.		*Eggs.*	*Other Meatstuffs.*	*Total*
1.	Weight	17.9	82.1	100
	Value	17.4	82.6	100
2.	Weight	20.3	79.7	100
	Value	17.3	82.7	100
3.	Weight	19.2	80.8	100
	Value	16.3	83.7	100
4.	Weight	19.0	81.0	100
	Value	15.7	84.3	100
5.	Weight	19.3	80.7	100
	Value	16.3	83.7	100
6.	Weight	17.6	82.4	100
	Value	13.6	86.4	100
7.	Weight	23.4	76.6	100
	Value	17.3	82.7	100
Whole Group.	Weight	19.5	80.5	100
	Value	16.2	83.8	100

The most important fact established from the foregoing Tables is that the relation between income and consumption by weights and values of " meatstuffs " as defined in this study is clear. But when individual types of " meatstuffs " and income are compared a less clear relationship is established bordering on no relationship at all in the cases of some types of " meatstuffs." It appears, therefore, that meatstuffs closely related in the household budget must be considered together in relation to incomes, as individual consideration of " meatstuffs," the consumption of any one of which is closely related to the consumption of any other, is a purely artificial process. Values per unit weight also show a rather curious trend but when certain allowances are made these are understandable. Prices per unit weight increase with increases in income but not as much as is popularly expected. The reason for this is that while the relatively well-to-do normally pay more for " meatstuffs " it is not the case that they always buy at a much higher price per unit weight. Relatively poor people can afford to buy only in small quantities and prices for small amounts are relatively higher per unit of product purchased. Working class families in good circumstances pay cash for purchases when it is available. But in times of economic stress an attempt is made to meet adversity by lowering quantities and qualities purchased as well as by resorting to trade credit. This leads to a relatively high cost per unit of " meatstuffs " purchased.

Large quantities of meat and fish are offered by auction in the Rhondda Valley, but while large households of small means can buy in this way, small households in similar circumstances cannot, for the quantities offered are too large and make too big a sum of money for them to pay. " Clubbing " is done to some extent to overcome this difficulty.

Consumption of " meatstuffs " and types of Households.

The consumption of " meatstuffs " in households of different types shows considerable variations. For simplicity in treatment households are classified as follows :—

Total Households.

Type 1. Households comprising adults and children.

Type 2. Households comprising adults only.

The average consumption and cost of " meatstuffs " in the whole group has been treated in detail earlier in this work, and it is presented here for comparison with the others. Type 1 shows a higher number of persons per household and of course a higher number of adult equivalents, with an average income 1/- lower

per person. The average consumption of untreated butchers' meat is lower by about 1 oz., while average consumption of cured meat and eggs is slightly lower, but consumption of prepared and tinned meat and fish is slightly higher. Of all " meatstuffs " by weight, average consumption is 0.08 lb. below that of the whole group.

The number of households in Type 2 is much smaller than in Type 1, and persons and adult equivalents per household are considerably lower. Average income is nearly 3s. higher than in the average of the whole group and nearly 4s. higher than Type 1; this is partly but not wholly due to households being smaller. The consumption of untreated butchers' meat and cured meat is much higher and that of prepared meat, tinned meat and eggs lower than for any of the other types of households. For each individual " meatstuff " itemised the greatest positive and negative difference occurs between Types 1 and 2.

Type 2 shows an average consumption of " meatstuffs " of about 3 oz. per adult equivalent higher than Type 1 and 1½ oz. per adult equivalent higher than in the whole group (Table XVIII).

A comparison of expenditure on each kind of " meatstuff " indicates that Type 2 spend 4d. per adult equivalent more on untreated butchers' meat than Type 1 and 3d. more than the average of the whole group. Differences in expenditure are very much smaller for cured meat, but the trend of the differences is the same. The table shows quite clearly that expenditure on prepared and tinned meat is greatest in households with children and least in households of adults only, but the opposite is true

TABLE XVIII.

Consumption of Meatstuffs per Adult Equivalent by types of households (Weight).

Particulars.	*Whole Group.*	*Type 1.*	*Type 2.*
Households	259	162	97
Persons per household	4.78	5.55	3.47
Adult equivalents per household	3.99	4.30	3.47
	s. d.	s. d.	s. d.
Income per person	11 3	10 3	14 2
	lb.	*lb.*	*lb.*
Untreated Butchers' Meat	1.08	1.02	1.18
Cured	0.35	0.33	0.39
Prepared and Tinned Meat	0.34	0.36	0.27
Fish	0.32	0.33	0.30
Eggs	0.50	0.47	0.54
Total Meatstuffs	2.59	2.51	2.68

TABLE XIX.

Value of Meatstuffs per Adult Equivalent by types of households.

Particulars.	*Whole Group.*	*Type 1.*	*Type 2.*
Households	259	162	97
Persons per Household	4.78	5.55	3.47
Adult equivalents per household	3.99	4.30	3.47
	s. d.	s. d.	s. d.
Income per person	11 3	10 3	14 2
	Pence.	*Pence.*	*Pence.*
Untreated Butchers' Meat	13.73	12.87	15.42
Cured Meat	5.22	4.88	5.89
Prepared and Tinned Meat	3.33	3.41	2.95
Fish	2.70	2.81	2.46
Eggs	5.00	4.82	5.35
Total Meatstuffs	29.98	28.79	32.07

of expenditure on eggs. Households with adult members only spend most on " meatstuffs " and households with children least. The expenditure per adult equivalent is : general average—2s. 6d.; Type 1—2s. 5d.; Type 2—2s. 8d. (Table XIX).

The differences in expenditure on " meatstuffs " are not wide, but it must be realised that the method of presentation of data on the basis of adult equivalents is in some degree responsible for narrowing the variations. As children have been converted to adult equivalents the effect is to lower the divisor while the dividend remains the same. It follows that the quotient—which is the average expenditure figure—is raised in proportion to the decrease in the divisor, and for households containing only adults no decrease in the size of the divisor is possible. Consequently the differences expressed on the basis of persons would be relatively greater. Still, the fact remains that adults consumed most and spent most on the best kind of " meatstuffs."

Sources of Supplies of " meatstuffs " and Income.

An attempt was made to ascertain the sources of supply of the most important and easily defined types of " meatstuffs " and records of sources were obtained relating to untreated butchers' meat, cured meat and eggs.

On an average slightly over 41 per cent. by weight of untreated butchers' meat was imported and slightly under 59 per cent. home produced. While there is a tendency for the proportion of supplies imported to fall and the proportion of home produced to rise with increase in income, there is by no means a regular relation between income and proportions of home-killed and imported. Imported beef is mainly chilled and mutton and lamb is all frozen, some frozen pork and offals are also consumed, but not much (Table XX).

Proportions by value show precisely the same tendency as proportions by weight, but proportions for imported meat are

TABLE XX.

Sources of supply of Untreated Butchers' Meat in income groups by weight.

Group.	*% Imported.*	*% Home Killed.*	*Total.*
1	61.89	38.11	100
2	42.34	57.66	100
3	45.82	54.18	100
4	23.98	76.02	100
5	—	100.00	100
6	8.00	92.00	100
7	12.41	87.59	100
Whole Group ..	41.51	58.49	100

TABLE XXI.

Sources of supply of Untreated Butchers' Meat in income groups by value.

Group.	*% Imported.*	*% Home Killed.*	*Total.*
1	52.46	47.54	100
2	33.89	66.11	100
3	39.59	60.41	100
4	19.61	80.39	100
5	—	100.00	100
6	6.58	93.42	100
7	10.78	89.22	100
Whole Group ..	33.51	66.49	100

lower and for home produced meat higher in all instances. This is due to the fact that imported meat is cheaper per unit weight than home produced. Average values indicate that one third of expenditure is for imported meat and two-thirds for home produced (Table XXI).

Roughly 20 per cent. by weight of cured meat supplies was imported and 80 per cent. home produced. There is a tendency for the proportion of imported to decrease and home produced to increase as income rises. Groups 3 and 4 are exceptions and Group 7 a notable exception (Table XXII). Proportions of imported cured meat are slightly lower by value than by weight, and those for home produced cured meat slightly higher. The relation of income to source of supply indicates a tendency for home produced cured meat to increase with increases in income; but Groups 3, 4 and 7 are exceptions (Table XXIII).

TABLE XXII.

Sources of Supply of Cured Meat in income groups by weight.

Group.	% *Imported.*	% *Home Killed.*	*Total.*
1	47.72	52.28	100
2	13.04	86.96	100
3	15.42	84.58	100
4	15.15	84.85	100
5	—	100.00	100
6	—	100.00	100
7	24.00	76.00	100
Whole Group ..	20.24	79.76	100

TABLE XXIII.

Sources of Supply of Cured Meat in income groups by value.

Group.	% *Imported.*	% *Home Killed.*	*Total.*
1	42.69	57.31	100
2	11.24	88.76	100
3	13.07	86.93	100
4	15.25	84.75	100
5	—	100.00	100
6	—	100.00	100
7	22.02	77.98	100
Whole Group ..	17.32	82.68	100

The average proportion by weight of imported eggs is 14 per cent., and home produced 85 per cent. Only the two lower income groups show higher than average proportions imported. There is a marked decline from Group 3 to Group 6 in proportions of imported eggs. But the figures in Group 7 show a small rise. The proportions of home produced show exactly the opposite tendency, tending to rise with increases in income. One factor which must disturb the relative proportions of eggs imported and home produced is the fact that nearly 10 per cent. of householders kept laying birds. This explains the exceptionally high proportion of eggs home produced (Table XXIV).

The proportions of imported and home produced eggs by value are almost the same as by weight. Imported supplies amount to 12.5 per cent. and home produced to 87.5 per cent. Proportions by income groups show a tendency for imported supplies to fall and home produced supplies to rise with increases in income. But the proportion of home-produced eggs by value

and weight is higher in the lower income groups than for any other commodity in this study (Table XXV).[7]

TABLE XXIV.

Sources of Supply of Eggs in income groups by weight.

Group.	% *Imported.*	% *Home Produced.*	*Total.*
1	15.67	84.33	100
2	20.07	79.93	100
3	11.27	88.73	100
4	6.06	93.94	100
5	4.76	95.24	100
6	4.76	95.24	100
7	6.45	93.55	100
Whole Group ..	14.50	85.50	100

TABLE XXV.

Sources of Supply of Eggs in income groups by value.

Group.	% *Imported.*	% *Home Produced.*	*Total.*
1	13.83	86.17	100
2	17.32	82.68	100
3	9.77	90.23	100
4	5.18	94.82	100
5	3.74	96.26	100
6	3.95	96.05	100
7	5.14	94.86	100
Whole Group ..	12.50	87.50	100

It is probable that the proportions of untreated butchers' meat by value and weight shown as imported is too low. Comparatively few consumers could distinguish between imported beef and home-killed beef at sight, while the number capable of distinguishing similarly between chilled and frozen beef was very much smaller. Nearly all housewives could distinguish between home killed and imported beef in the process of cooking, for they claimed that shrinkage in both chilled and frozen beef is much higher than in the home-killed beef. Many consumers very definitely believe that home killed meat is the most economical in the long run, and would prefer it if material circumstances permitted; many others actually prefer imported, maintaining that it is more tender than the kind of home killed beef they can get. Considerable numbers of consumers express the view that imported is more hygienic as they believe the processes of chilling and freezing to which imported beef is subjected arrests and possibly prevents the growth of "germs."

Imported supplies of mutton and lamb are, of course, all frozen. There is actually a strong preference for Canterbury lamb, chiefly owing to its high quality in relation to price. But some householders also regard it as safer from the standpoint of health owing to the fact that it has been subjected to the process of freezing. Some of its popularity arises as a reaction to the fact that in some households there is a profound dislike for Welsh mutton and lamb because sheep and lambs in the district get a lot of their food from scavengers' buckets and rubbish tips. There is no doubt that the Welsh sheep is easily the most placid

[7] This is probably due in large measure to the period of the year, *i.e.*, end of May.

pedestrian of Rhondda streets and possibly the most thorough scavenger of Rhondda rubbish tips.

Imported pork was consumed in small quantities, but has yet to obtain anything like a constant place in the dietary of the people; imported veal was consumed in very small quantities, some of the edible offals were imported, while all the poultry consumed was home-produced.

Cured meat of imported origin had obtained a firm hold and had a regular place in the dietary of the people in the district before the advent of Import Duties and the Pigs and Bacon Marketing Schemes. Since then there has been a tendency for the margins in prices of home produced and imported supplies to be narrower and the incentive to buy the best imported supplies has largely disappeared. People in the lower income groups have now been obliged to shift their demand for bacon from the best to other imported supplies in response to ever-increasing hardships in material circumstances.

It was extremely difficult to trace the sources of supplies of cured meat from records of purchases by consumers. Few of them knew the sources of the purchases exactly, and it appears that the statement of proportions by sources is fairly heavily weighted in favour of home produced supplies.

The proportion of eggs imported appears low and the proportion of home produced high. But nobody thoroughly familiar with the Rhondda Valley would express much surprise at the relative proportions, for back-yard poultry flocks are fairly common.

THE MILK MARKETING SCHEME IN WALES, 1934-5.

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The chief economic intention of a Scheme for organised marketing is to guarantee to the producer a reasonable return from the sale of his product. Owing to the regional structure of the Milk Marketing Scheme, and the differential returns obtained by producers situated in different regions, it will be necessary to consider the underlying causes of these variations. In this connection the institution of the Scheme has been instrumental in placing at our disposal a great deal of information concerning almost every aspect of the industry. It has furnished accurate statements of the intensity of production, and the

extent to which production has been influenced by the new conditions. But the effect of the depression in other branches of agriculture and the possibility of a change in the utilisation of milk previously used on farms must be borne in mind, especially in the case of Wales.

The division of the Principality into two regions, North and South, is in some respects purely arbitrary in so far as they are not composed of entirely homogeneous units, either from the point of view of production or of consumption. The imposition of a uniform set of marketing conditions involving the acceptance of contractual obligations might not therefore react in the same way on all producers owing to the different ways and degrees to which it affects their customary farming practice. Even so, however, the available statistics bring out the chief characteristics of each region taken as a whole. As Monmouth has been placed in the West Midland a certain amount of consideration must be given to that region.

The main feature during the second contract period has been the increase in the number of contracts and in sales thereunder. Between December, 1933, and September, 1935, the total number of contracts increased by 13.6 per cent. The regional increases have been by no means uniform, while one region, the South Eastern, has shown a slight reduction. The largest increases have occurred in the western regions, and amongst these the increases for North and South Wales were 45.9 and 27.6 per cent. In the West Midland conditions appear to have been less favourable to expansion, the increase of 2.9 per cent. over the same period, being well below the average for England and Wales.

Total contract sales of milk have increased from 716,437,000 gallons in the first operational year of the Scheme to 856,004,000 gallons during the second contract period; an increase of 19.4 per cent. As would be expected from the foregoing observation, Wales obtained a full share in this increase. In North Wales total contract sales increased from 13,862,000 gallons in 1933-4 to 18,310,000 gallons in 1934-5, an increase of 32 per cent. In South Wales, where there are nearly three times more wholesale contracts registered than in North Wales, there has been an increase of 35.1 per cent. from 24,605,000 to 33,259,000 gallons In the West Midland the increase has been about 16 per cent., which approaches the average for all regions. The average increase in milk production in Wales has, therefore, been much higher than the average increase for the country as a whole. This may, perhaps, be accounted for by the price pooling system provided in the Scheme, whereby producers in the advantageously

situated regions make a net contribution by way of inter-regional compensation towards the maintenance of the pool prices of the more distant regions with more varying production, and the relative effect of this on the producers of the " surplus " regions. How far this goes to explain the increased production in Wales may be seen by a consideration of the net contribution made to or received from the inter-regional compensation fund and the actual prices obtained.

(1) Nominal Contract Prices (" Liquid ") and Actual Realised Prices.

The effects of the levies are, however, influenced by the nominal producers' (and actual buyers') prices for liquid milk. During the contract period 1934-5 these were identical for all regions. This equalising of contract prices influenced to some extent the relative weight of the burden of levies on those regions which made net contributions to the Compensation Fund and brought nearer the possibility of a national pool price being realised.

During October and November the contract price stood at sixteen pence per gallon, while from December to February inclusive it advanced by one penny to the Winter peak. In March and April it was down again to its previous level, while in May[1] and June there was a significant fall to twelve pence per gallon. In July and August it had risen to thirteen pence, while in September it had further advanced to sixteen pence per gallon. The price per dozen monthly gallons was 15s. 1d. as against 18s. 9d. for all regions exclusive of the South Eastern during the first contract period.

But actual realised values over the year depend on the quantities sold in the months of higher and lower prices, and on the quantities sold under the " Milk in Schools " Scheme, for which a lower price was received, although in this latter case the producers did not bear the entire burden. Taking these factors into account the actual realised value of liquid milk over the whole country was 15.07 pence per gallon, which was about 1¼d. per gallon higher than the corresponding figure for the previous year.

Turning to the position of the Welsh regions it is observed that a feature in the North Wales trade was the increase in the sales of liquid milk during the months of July and August. This was probably due in part to the inroad of large numbers of visitors to the resorts. In South Wales the sales were steadier, while the total for the higher priced (Winter) period was slightly in excess

[1] In May, 12½d. with publicity contribution.

of that for the Summer. The weighted average realisation value of " liquid " milk was about 14.82 pence per gallon. In North Wales it was just under 14.94d., while in the West Midland it was about 15.12d. per gallon.[2]

As the actual value realised by producers in each region is strongly affected by the proportions sold liquid and for manufacturing it is necessary to set out this position.

(2) Liquid and Manufacturing Sales.

Milk which is surplus to liquid requirements finds its way into the manufacturing market and the price paid for it varies according to the manufacturing process in which it is utilised. These manufacturing prices are considerably lower than those paid for liquid. It follows, therefore, that an undue proportion of manufacturing milk has a depressing effect on the pool prices ultimately payable to producers.

During 1934-5 the greater part of the increase in total contract sales was accounted for by an expansion in the manufacturing market. The proportions of liquid and manufacturing sales were 64.74 and 35.26 per cent., while for the previous year the corresponding proportions were 73.11 and 26.89 per cent. respectively. As would be expected, May and June were the months showing the highest manufacturing proportions in both years. The increase in the proportion of manufacturing milk during 1934-5 was accompanied by a reduction of 0.15 pence in the average utilisation value, but this was more than offset by an increase in the subsidy, which worked out at 0.33 pence per gallon during the last contract as against 0.5 pence for the previous year. The average realisation values (inclusive of subsidy) were therefore 5.64 and 5.46 pence respectively. The figure for the last six months of 1933-34 was 5.56 pence.

In North Wales during the last contract period manufacturing sales increased by 126 per cent. while liquid sales suffered a reduction of 8.3 per cent. The monthly proportions of manufacturing ranged from 48.57 per cent. in October to 63.49 per cent. in June, with the yearly average at 52.89 per cent., which was far in excess of the average for the whole country (see Table I).

The utilisation of the manufacturing milk along with the realisation values for the different classes are set out in Table II. It is seen that in North Wales over half was used for cheese making, while butter accounted for 42.3 per cent. Over 98 per

[2] Not including the differential prices received for milk sold under the Milk in Schools Scheme.

cent. of the manufacturing milk therefore passed into the lowest price classes. It is worthy of note, however, that there has been a progressive increase in the proportion used for butter making

TABLE I.

Proportions of Liquid and Manufacturing Milk. 1934-5.

Month.	*North Wales.*		*South Wales.*		*All Regions.*	
	Per cent.		*Per cent.*		*Per cent.*	
	Liquid.	*Manufacturing.*	*Liquid.*	*Manufacturing.*	*Liquid.*	*Manufacturing.*
Oct.	56.43	43.57	72.61	27.39	73.09	26.91
Nov.	52.18	47.82	75.42	24.58	74.02	25.98
Dec.	55.14	44.86	74.56	25.44	71.86	28.14
Jan.	56.31	43.69	71.47	28.53	71.41	28.59
Feb.	53.84	46.16	70.56	29.44	69.79	30.21
Mar.	46.94	53.06	65.75	34.25	66.48	33.52
Apr.	40.01	59.99	52.34	47.66	59.75	40.25
May	37.51	62.49	45.98	54.02	53.73	46.27
June	36.51	63.49	46.45	53.55	52.75	47.25
July	41.53	58.47	53.19	46.81	57.65	42.35
Aug.	52.59	47.41	62.91	37.09	63.74	36.26
Sept.	53.14	46.86	67.94	32.06	69.20	30.80
Year	47.11	52.89	61.67	38.33	64.74	35.26

which has probably been due to the low price of cheese. Thus, in November, 1934, about 63 per cent. was used for cheese making, and butter accounted for 36.5 per cent., while by the following

TABLE II.

Utilisation of Milk for Manufacturing Purposes. 1934-5.

Products.	*Percentage of Total.*			*Average Utilisation Value per Gallon.*
	North Wales.	*South Wales.*	*All Regions.*	(*pence*).
Butter	42.3	17.2	27.5	4.07
Hard Cheese	56.1	58.1	30.3	3.50
Soft Cheese	—	—	0.4	7.50
Condensed Milk	0.4	2.5	16.6	6.00
Condensed Milk for Export	—	—	2.6	4.04
Milk Powder	—	13.4	4.1	4.50
Fresh Cream	1.2	3.0	13.9	7.50
Ice Cream	—	—	1.0	7.50
Tinned Cream	—	5.5	2.5	5.00
Chocolate	—	—	—	—
Sterilised Milk for Export	—	—	—	6.00
Other Goods	—	0.3	1.1	9.00
Total or Weighted Average	100.0	100.0	100.0	4.81*

* Excluding subsidy; including subsidy 5.64d.

September the position had been reversed. The only other products which figured in the North Wales returns were fresh cream and condensed milk, but quantities were very small compared with the proportions for the country as a whole. The average value realised by the sale of manufacturing milk (exclusive of the subsidy) was 3.79 pence as compared with 4.81 pence per gallon for all regions.

In South Wales during 1934-5 both liquid and manufacturing sales were higher than in the preceding year, although the manufacturing market showed a greater proportional increase than did the former. The range in the monthly proportions of manufacturing sales were from 24.58 in November to 54.02 per cent. in May, while the yearly average at 38.33 per cent. was slightly in excess of that for England and Wales. As in the case of North Wales, the greater part of this surplus was used for cheese making, while butter which claimed 17.2 per cent., was next in order of importance. The proportion which went to milk powder at 13.4 per cent. was well above the average for all regions, although this category was again not among the most remunerative. Smaller proportions were also used for creaming and condensing. It is seen, therefore, that here again the predominant part of the manufacturing milk was utilised in the lowest price classes, and although South Wales fared somewhat better than its northern counterpart, it was still well below the position of all regions in the aggregate. The average realisation value (excluding the subsidy) was 4.01 pence per gallon. In the West Midland during the same period 54.55 per cent. was manufactured, and the average realisation value worked out at 4.48 pence per gallon.

Although the realised values of manufacturing milk are pooled for the whole country and the average price credited to the Pool of each region irrespective of the use of milk sold for manufacturing in the region, it is necessary that these figures should be borne in mind when assessing the value of the Scheme to the milk producers of Wales.

Before discussing the actual pool prices it will be convenient to have the facts as regards the levies in mind, for these, together with the prices for liquid and manufacturing milk and their relative quantities, determine the prices finally paid.

(3) Deductions from Contract Prices.

A significant feature of the last contract period has been the appreciable increase in the average pool deductions, which were just over a penny per gallon higher than in the preceding

year. This was probably due to the lowering of the contract prices for liquid milk and the expansion in the volume and consequent decrease in the realisation value for manufacturing milk. The deductions for North and South Wales, and the weighted average for all regions in 1934-5 are shown below.

TABLE III.

Deductions from Contract Prices. 1934-5.

Month.	*North Wales.*	*South Wales.*	*All Regions.*
		Pence per Gallon.	
Oct.	3.25	2.25	2.44
Nov.	2.75	2.00	2.19
Dec.	3.00	2.50	2.65
Jan.	2.75	2.25	2.54
Feb.	3.50	3.00	3.01
Mar.	3.25	3.00	3.13
Apr.	4.25	3.75	3.94
May	2.75	2.50	2.65
June	2.75	2.50	2.46
July	3.50	3.00	3.16
Aug.	3.00	2.75	2.99
Sept.	3.50	3.25	3.27
Average	3.18	2.73	2.88

The mean annual deduction for North Wales was greater than the corresponding average for all regions and the increase over the previous year also greater than the general increase, while for South Wales the reverse was the case in both instances. The monthly amounts of the deductions did not exhibit any strict seasonal trends, but the averages for the Summer months were in each case higher than those for the Winter. In the preceding year the reverse was the case. The lowest deductions were invariably in the South Eastern, Eastern, and Southern Regions of England, the average for the former being only 2.2 pence per gallon. The highest amounts occurred in the Far Western and, curiously enough, the West Midland Region, the average for the latter being 3.81 pence per gallon. It is seen therefore, that a low deduction is compatible with a rich intensive dairying district adjacent or within easy reach of a densely peopled area affording a lucrative market for liquid milk, while a high deduction almost inevitably occurs in a less favoured region which has to seek an outlet for its milk in the least remunerative uses. These deductions are, however, of small significance to producers on wholesale contract situated in regions which receive a net contribution from the inter-regional compensation fund, but are of much greater importance to producer-retailers in so far as they form the basis for the assessment of levies.

(4) Producer-Retailers' Levies.

The payments made by producer-retailers as their contribution towards the maintenance of the pool prices of their respective regions are equal to the inter-regional compensation levy plus three-fourths of the difference between (*a*) the contract price for liquid milk (less the inter-regional compensation levy), and (*b*) the regional pool price. As would be expected from the foregoing observations on the deductions the levies during 1934-5 were appreciably higher than in the preceding year. The average for England and Wales during the last contract period was 2.45d. as against 1.56 pence in the previous contract. These figures do not include the allowance for level delivery premium or for guaranteed quality premium which has been available since May, 1935.

TABLE IV.

Producer-Retailers' Levies. 1934-5.

Month.	*North Wales.*	*South Wales.*	*All Regions*
		Pence per Gallon.	
Oct.	2.62	1.87	2.02
Nov.	2.31	1.75	1.90
Dec.	2.62	2.25	2.36
Jan.	2.43	2.06	2.28
Feb.	3.00	2.62	2.64
Mar.	2.87	2.68	2.75
Apr.	3.81	3.43	3.55
May	2.43	2.25	2.31
June	2.37	2.18	2.13
July	3.00	2.62	2.70
Aug.	2.56	2.37	2.52
Sept.	3.06	2.87	2.89
Unweighted Average ...	2.75	2.41	2.50
Weighted Average	2.63	2.37	2.45

The average for North Wales for 1934-5 at 2¾d. was again above that for the whole country, while that for South Wales had fallen slightly below, thus bringing out the effect of the relative proportions of manufacturing milk to the total contract sales of the two regions. In the West Midland the average worked out at 2.85 pence per gallon. The "allowance for level delivery" was fixed at ½d. throughout the year. Broadly speaking, however, those producer-retailers who did not sell by wholesale contracts were called upon to pay levies at these rates less the allowance for the level delivery premium, while those who sold also by wholesale were called upon to pay the gross rates. The actual average rate of levies cannot be stated because proportions

are unknown. From and including the month of May, 1935, the producer-retailers who qualified received the Accredited Producers' premiums. With these facts in mind we may proceed to a consideration of the pool prices.

(5) Pool Prices.

The pool prices are the result of (*a*) sales of liquid milk at contract prices, (*b*) sales of manufacturing milk at the monthly value realised over the whole country, (*c*) net contributions made by producer-retailers in the region, (*d*) net contribution made to or received from the Inter-Regional Compensation Fund.

In England and Wales during 1934-5 the net result of these transactions was to increase slightly the weighted average pool price from 11.88 to 11.99 pence per gallon.

As may be anticipated from the foregoing observations, North Wales did not enjoy such favourable conditions as did all regions in the aggregate (see Table V). During 1934-5 the total contract sales in North Wales contained a greater proportional element of manufacturing milk, the greater part of which went into the least remunerative uses. The weighted average pool price was 11.51 pence per gallon as against 11.88 pence in the previous year. Those of other regions, however, such as the Far Western (11.39d.) and West Midland (11.47d.) were lower than that for North Wales, but the higher prices realised in certain of the more favourably placed regions exerted such a counter balancing influence as to raise the general average above that for the North Wales region.

TABLE V.

Pool Prices. 1934-5.

Month.	*North Wales.*	*South Wales.*	*All Regions*
		Pence per Gallon.	
Oct.	12.75	13.75	13.56
Nov.	13.25	14.00	13.81
Dec.	14.00	14.50	14.35
Jan.	14.25	14.75	14.46
Feb.	13.50	14.00	13.99
Mar.	12.75	13.00	12.87
Apr.	11.75	12.25	12.06
May	9.25	9.50	9.35
June	9.25	9.50	9.54
July	9.50	10.00	9.84
Aug.	10.00	10.25	10.01
Sept.	12.50	12.75	12.73
Weighted Average	11.51	12.05	11.99

In South Wales, however, the average value realised by the sale of liquid milk was slightly above, and the proportion of manufacturing milk almost coincident with the average for England and Wales. Its weighted average pool price was slightly above the general average at 12.05 pence per gallon. The corresponding figure for the previous year was 11.70 pence per gallon.

The relative positions of North and South Wales during 1934-5 may best be summarised as follows :—

	North Wales.	*South Wales.*	*West Midland.*	*All Regions.*
		(Pence per Gallon).		
Average Nominal prices for Liquid Milk	15.09	15.09	15.09	15.09
Average realised price all contract sales	14.72	14.80	14.79	14.87
Average realised value (Liquid)	14.94	14.82	15.12	15.07
Average utilisation value of " Manufactured " within Region*	3.79	4.01	4.48	4.81
Value of Manufactured credited to Region†	5.64	5.64	5.64	5.64
Weighted average Pool Price	11.51	12.05	11.47	11.99
Average Transport Charges	2.09	2.58	1.98	1.83
Weighted Average Producer Retailers' Contribution‡	2.27	1.92	1.79	1.99

* Not including subsidy.

† Including subsidy.

‡ Allowing for level delivery premium but not for guaranteed quality premium.

From the figures available it is estimated that South Wales received a small net contribution and North Wales a considerable net contribution from the Inter-Regional Compensation Fund. The operation of the Scheme was therefore of definite advantage to both regions.

(6) Provisions for Secondary Prices.

The control of the nominal producers' prices might not, of itself, give that stability to the industry which was expected of the Scheme. In order that its intentions might not be frustrated, provisions for the elimination of under-cutting have been carried through to the consumers' end of the distributive process. This has been done by fixing minimum prices for all sales of liquid milk subsequent to the first sale by producers at the stipulated contract price, while producer-retailers have also to conform to the price regulations laid down.

According to these provisions for 1934-5 wholesalers were not to sell milk to retailers at a price less than the regional price plus 1½d. per gallon, but for large quantities delivered to one buyer at one place within twelve consecutive hours the price charged was fixed at not less than the regional price plus 1¼d.-½d.

per gallon for consignments varying from 500 to 1,500 gallons respectively. A fine of 2s. per gallon might be imposed for every gallon sold in contravention to these regulations.

If these retailers, however, sold this milk or permitted the milk thus delivered to be sold at a cut price, or if they sold the milk otherwise than by retail for liquid consumption, wholesalers were not to supply any more milk to them until the expiry of the existing contract.

The minimum retail prices were fixed by "areas." These were not strictly synonymous with certain regions or any combination of such. They referred in part to the kinds of local government authorities under which they were administered, and, in part, to the population of these local government divisions. The only region which was, to a certain extent, retained as a separate entity for this purpose was the South Eastern. During the contract period under review the minimum prices per twelve monthly gallons were as follows :—

	Per twelve monthly gallons. s.	d.
(1) All Rural Districts, and Urban Districts, and Municipal Boroughs of less than 10,000 inhabitants	23	4
(2) Urban Districts, Boroughs, and County Boroughs with a population exceeding 10,000 but under 25,000	25	0
(3) Urban Districts, Boroughs, and County Boroughs outside the South Eastern Region with a population exceeding 25,000	26	0
(4) Urban Districts, Boroughs, and County Boroughs within the South Eastern Region with a population exceeding 25,000, including the City of London and the Metropolitan Police District	26	8

On the consumers' side it is rather disconcerting to find that retail prices have again increased slightly. During the first contract period the average increase was just under a ¼d. per quart, while at the end of the second contract it was just under a ½d. per quart higher than in 1932-3. The exact effect in Wales is unknown, but here also it is almost certainly that of a slight increase in retail prices. The increase in small towns and villages has been higher than that in large towns.

The task of marketing the total milk supply of England and Wales in the common interest of all producers is a difficult one. The performance of this function through the Marketing Scheme has, however, been accompanied by an appreciable measure of success. Since its inception the majority of producers have received better prices than they did previously, although others have suffered a reduction. But the principle of regional compensation was implicit in the Scheme. The producers in regions where milk had special advantages in competitive selling, whether

by reason of adjacency or by relatively small variations in supply, or because of the main characteristics of its uses, were still better remunerated than those in less fortunate regions. The maintenance of producers' prices has then been ensured by the institution of a regional pooling system for their mutual benefit without at the same time entirely forsaking the rent element in profit, which the more favourably situated producers would inevitably have enjoyed under the old system of unrestricted competition. The stability thus created has given many producers increased initiative, while many new producers have entered the dairying industry from other branches of agriculture.

Social considerations have not been overlooked, as evidenced by the "Milk in Schools" Scheme, which has as its object the provision of milk for school children at a reduced price, and the Accredited Producers' Scheme, which aims at the production of a safe milk supply. But the former measure also expands the liquid market, while producers participating in the latter receive a slightly higher return, although in the case of Wales and Monmouth the producers bear a part of the cost of the veterinary services. In both these instances, therefore, the interests of producers and consumers are not antagonistic but complementary. On the whole, progress in accreditation in Wales has been very slow. The number of accredited producers in May and October 1935, were :—

	North Wales.	*South Wales.*	*West Midland.*	*England and Wales.*
May	204	43	146	2,855
October	553	343	874	11,228

It is also unfortunate that in Wales, except in Anglesey, where special conditions prevail, the development of the Milk in Schools scheme has been somewhat slower than in the country generally. While consumers are bearing some small extra burden of retail prices at any rate partly as a result of the Scheme, the economic position of Welsh producers has improved, and measures for improvement of supply have been placed at the disposal of producers and Local Authorities.

SOME COSTS OF MANUFACTURING MILK IN WELSH FACTORIES.

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A general movement away from farm conversion of milk has for many years been encouraged by the attraction of the expanding milk market, and this tendency has continued in spite

of the scheme for subsidising farm cheese-making. Sales of milk in liquid form resulted in more frequent and regular cash returns as the ripening period in the case of some varieties of cheese necessitated some delay, and the possibility of physical deterioration made the business somewhat risky. The relatively heavy labour involved in the process of manufacture also militated against the development or continuation of the system, even though under certain conditions it offered a comparatively good return.

With the expansion of the demand for milk in this country, consequent upon growth of urban areas, the necessity of obtaining milk from ever widening zones compelled persons in the distributive trade to establish creameries in country districts. These were used for the assembly, processing and dispatch of milk to distant centres; in addition they were needed for the local conversion of supplies that were surplus to liquid requirements. Several depots of this character are to be found in Wales.

A Milk Depot and Cheese Factory.

In one case farmers in the district purchased the business outright and have subsequently run it as a co-operative society. The land in the vicinity of the creamery is comparatively fertile and milk production constitutes one of the chief systems of farming. The factory obtains its milk from surrounding farms, and a radius of about eight miles is covered. Previous to October, 1933, a large proportion of the milk was pasteurised and despatched to city buyers, principally in Birmingham, but appreciable quantities were also sent to London. Producers generally deliver their own milk to the factory, as the latter does not undertake collection.

Producers sign a yearly contract to dispose of all their milk to the creamery with the exception of small quantities retailed from the farms, and these contracts are very well observed. In most years the society has been able to show a reasonable profit; it was, however, unable at all times to find a market for all the milk, and in consequence attention was paid to the possibility of cheese production, especially during the summer months. In recent years, however, the quantity of cheese made has shown a rapid increase and during 1934 almost all the milk handled was manufactured into Cheshire cheese.

The financial year of the society ends on January 31, and for the year February, 1933, to January, 1934, about half the milk delivered to the factory was sold in liquid form. The advent

of the Milk Marketing Board in October, 1933, made an enormous difference to the creamery, and since that time sales of milk have been on a considerably reduced scale; the creamery which was formerly a milk depot became almost entirely a cheese-making factory.

A study has been made of the financial and other transactions of the society for the years 1933 and 1934, and some figures relating to the costs of running the establishment have been obtained.

In addition to the manufacture of cheese the creamery has undertaken the production of whey butter. At the present time this forms a very important part of the work, and the enterprise is proving quite remunerative. There is no demand for whey in the district, only a small proportion of the producers undertake the rearing or fattening of pigs, and in consequence the factory has experienced some difficulty in disposing of the whey. For some time it was offered to farmers at ½d. a gallon, but later the price was reduced to ¼d. a gallon.

Factories cannot allow all kinds of by-products and residues to run into rivers; the water may become unsuitable for drinking and other purposes, and if it is required by other users the factory may be prevented from polluting it. Again some by-products, especially whey, prove injurious to fish, and it is not uncommon for an injunction to be granted restraining factory owners from allowing such products to flow into streams.

After the extraction of fat from the whey the resultant product, in the farmers' view, possesses very little feeding value and they are not prepared to haul it to the farms even when it is offered free. In order to utilise some of the whey available the society acquired a piece of land adjoining, erected a piggery upon it, and, during the last few years, store pigs have been purchased, then fattened and sold, as either porkers or baconers, on the local market. During the two years under review this side-line has appeared remunerative. A fairly considerable proportion of the whey available has been disposed of in this way, but the advisability of pursuing the enterprise depends very largely upon the prices of pigs and of feeding stuffs.

The quantity of milk supplied to the factory has shown an appreciable seasonal variation during the last two years; it reaches its highest point in June and its lowest in October. Until the advent of the Milk Marketing Scheme the price paid for the milk was determined monthly by the society and varied according to the price realised by the creamery for the milk and milk products sold. Since October, 1933, almost the whole of the

milk received has been converted into cheese; in 1984 only very small quantities were sold locally in liquid form, because the Milk Marketing Board refused the creamery a licence for depôt facilities.

The Cost of handling Milk.

The problem of isolating the cost of handling milk from that connected with cheese and butter manufacture was rendered difficult owing to the large monthly variation in the quantity of milk sold in liquid form. A sufficient number of employees was kept to deal with both the milk and cheese enterprises, but in general certain persons were able to turn from one to the other as required. The extent to which the milk was processed before sale varied according to the buyers' requirements. Some only required it to be brine cooled, others wanted it pasteurised.

The milk is delivered to the creamery in the morning by suppliers, consequently the cost of transit to the factory does not concern the creamery. The employees undertake the processing of that portion of the milk which is sold in liquid form; this is placed in churns and dispatched as early as possible. The results of the years' operations regarding the milk enterprise can be summarised as follows :—

Financial transactions of the Milk Enterprise.

		Total. £ s. d.		Per Gallon. d.
Receipts from Milk		7,108 17 11		9.94
Cost of Milk	.. £5,505 5 10		7.70	
Cost of Handling	.... 683 6 0		0.95	
Total Cost		6,188 11 10		8.65
Profit		£920 6 1		1.29

The quantity of milk sold in liquid form during the year was 171,559 gallons; this amounted to 40 per cent. of the total handled. The costs of this part of the business can be conveniently tabulated as follows :—

	Total Cost £ s. d.	Cost per Gallon. d.
Wages and Insurance	206 6 4	0.28
Light and Power	45 15 1	0.07
Office expenses	8 1 11	0.01
Marketing expenses	25 6 1	0.04
Audit and Bank Charges	10 9 6	0.01
Carriage	302 0 0	0.42
Miscellaneous	35 7 1	0.05
Depreciation	50 0 0	0.07
	£683 6 0	0.95

Rent only amounts to a very small sum, as the Society owns most of the land and all the buildings; the rent actually paid relates to a small piece of land adjacent to the factory. The outlay on this item is, therefore, lower than would be the case had the society to pay rent on all land and buildings.

The cost of processing and selling the milk over the twelve months was just under 1d. per gallon and the profit a little over 1¼d. a gallon. The price obtained for milk was very largely outside the control of the Society, and little could be done to reduce the cost of handling. Before the advent of the Milk Marketing Scheme the society aimed at a reasonable margin of profit, as the price paid to producers was fixed at about 2d. per gallon below that received by the factory. By adopting this practice a profit was assured on the milk enterprise. Profits, however, were returnable to members and suppliers as interest on share capital at a fixed rate and bonus on supplies.

The Cheese Enterprise.

The cost of cheese-making in this, as in other factories, depends very largely upon the annual throughput. When a factory is working at or near its full capacity overhead charges can be spread over a comparatively large quantity and under such conditions, the cost per unit of product will in general be relatively low. During 1933 the quantity of cheese made at this factory was much below that made in the following year and in consequence the difference in the cost of manufacture is quite appreciable.

Almost all the cheese made is of the Cheshire variety and towards the closing months of 1933 prices were comparatively favourable; there was a distinct rise in September and a fairly high level was maintained until the close of the year. As the factory was able to obtain supplies of milk for cheese production during the autumn months at a much lower figure than was formerly the case, the production of cheese proved remunerative for a short period. The creamery had manufactured considerable quantities, however, during the Spring and Summer months, and at that time, it was paying too high a price for the milk in relation to the price of cheese. Taking the financial year as a whole therefore, a loss was suffered on the cheese enterprise.

The financial transactions relating to the cheese enterprise during 1933 were as follows :—

			Total	Per lb.
			£ s. d.	d.
Receipts from Cheese			5,840 18 7	5.54
Cost of Milk	.. £4,631 18 2	4.89		
Manufacturing Cost	.. 1,423 10 5	1.85		
Total Cost			6,055 8 7	5.74
Loss			£214 10 0	0.20

The margin between the cost of the milk and the price received for the product was only 1.15d. per lb. whereas the cost of manufacture amounted to 1.35d. per lb. The items entering into the cost are given below :—

Item.	*Total Cost.*	*Cost per lb.*
	£ s. d.	d.
Wages and Insurance	581 5 4	0.55
Light and Power	161 11 6	0.15
Rent and Rates	12 11 5	0.01
Office expenses	31 1 8	0.03
Chemicals and Cloths	167 4 6	0.16
Marketing Expenses	97 3 3	0.09
Audit and Bank Charges	40 4 5	0.04
Carriage	110 12 11	0.11
Miscellaneous	93 15 5	0.09
Depreciation	128 0 0	0.12
	£1,423 10 5	1.35

The Butter Enterprise.

It is only at a few cheese factories that any attempts are made to utilise by-products; results at this factory, however, show that the manufacture of whey butter is a profitable sideline. Creameries in general attempt to sell the whey, but as no satisfactory outlet could be found for it by direct sale at this factory, attention was directed towards its utilisation. The financial transactions relating to the butter enterprise are as follows :—

	Total	Per lb.
	£ s. d.	d.
Receipts from whey butter	428 7 9	9.75
Manufacturing Costs	131 2 2	2.98
Difference	£297 5 7	6.77

During the year 252,872 gallons of milk were manufactured into cheese, the whey obtained yielded 10,586 lb. of butter, *i.e.*, 1 lb. of butter was obtained from the by-product of 24 gallons of milk. After the removal of the whey from the cheese vats the two enterprises of cheese and butter production are quite distinct. All expenditure incurred in treating the whey and the outlay upon the manufacture of the butter are therefore, charged against the

butter. The expenses connected with this enterprise are given below.

Item.	*Total Cost.* £ s. d.	*Cost per lb.* d.
Wages and Insurance	44 0 0	1.00
Light and Power	21 8 8	0.49
Salt and Chemicals	3 1 6	0.07
Carriage	17 3 10	0.39
Miscellaneous	13 8 2	0.30
Depreciation on Equipment	32 0 0	0.73
	£131 2 2	2.98

Just over one farthing per gallon was realised for the fat content of the whey. A good market has been established for the whey butter and the factory has not experienced any great difficulty in finding buyers. This sideline proved quite satisfactory during the year under review and the " profit " made more than offset the immediate loss on the cheese enterprise.

The Business in 1934-5.

The creamery had become almost entirely a cheese-making factory by the close of 1933, and nearly all the milk received in 1934 was manufactured. The quantity of milk passing into the factory was also considerably higher in the second year. Producers in the area were encouraged by the favourable prices obtainable for milk, and many turned to its production whilst several of the older suppliers increased their offerings. The net prices available to suppliers were, in fact, much higher than those usually paid by the creamery.

The market for Cheshire cheese during the year was very unfavourable, prices fell heavily from April to June and remained at a comparatively low level until October, when some recovery was shown. The price paid by the creamery for milk was much lower during 1934 than in the previous year, but with such an unfavourable market it is not surprising to find that it was unable to show a profit on cheese production.

		Total £ s. d.		*Per lb.* d.
Receipts from Cheese		11,167 9 8		4.27
Cost of Milk	.. £9,785 7 0		3.74	
Manufacturing Cost	.. 1,962 9 0		0.75	
Total Cost		11,747 16 0		4.49
Loss		£580 6 4		0.22

Had the factory been entirely dependent upon the cheese enterprise for its net income during the year it would have been

in rather severe difficulties. The cost of manufacturing at ¾d. per lb. was very reasonable, and showed a drop of over ½d. per lb. compared with the previous year. This is mainly due to the fact that the quantity made was about three times greater in the second year. During the summer of 1934 the factory was working at its full capacity and it is doubtful whether additional supplies could have been properly treated with the accommodation available. Additional machinery and more labour would have been needed to cope with further supplies. The items entering into the cost of cheese production are as follows :—

Item.	*Total Cost.* £ s. d.	*Cost per lb.* d.
Wages and Insurance	844 4 11	0 32
Light and Power	248 4 0	0.09
Rent and Rates	15 4 9	0.01
Office expenses	15 15 2	0 01
Chemicals and Cloths	367 3 9	0.14
Marketing expenses	121 10 9	0.05
Audit and Bank Charges	25 4 0	0.01
Carriage	32 4 11	0.01
Miscellaneous	164 12 9	0 06
Depreciation	128 4 0	0.05
	£1,962 9 0	0 75

The Butter Enterprise.

The butter producing enterprise, however, yielded a very substantial income to the creamery and was responsible for the net profit shown on the year's working. In brief the transactions are as follows :—

	Total £ s. d.	*Per lb.* d.
Receipts from Butter	1,021 8 10	9 38
Total Cost	183 9 2	1.68
Difference	£837 19 9	7 70

The cost of manufacture was lower in the second year owing principally to the higher throughput; at approximately 1¾d. a lb. it formed a very small proportion of the market value of the product and a very substantial margin of profit was realised by the factory.

The costs are as follows :—

Item	*Total Cost.* £ s. d.	*Cost per lb.* d.
Wages and Insurance	97 0 0	0.89
Light and Power	31 18 4	0.29
Salt and Chemicals	7 18 1	0.07
Carriage	1 6 10	0 01
Miscellaneous	13 10 11	0.12
Depreciation	32 0 0	0.30
Total	£183 9 2	1.68

Of course, were the factory able to dispose of the whey at ½d. a gallon without incurring any expenditure upon handling it, this would have yielded the equivalent of about 6d. per lb. of butter that could have been obtained. This possible income would, however, still be lower by nearly 2d. a lb. than that yielded by the production of the butter. Were the factory able to obtain ¼d. a gallon for the whey the income from that source would be lower by £211 than the profit on the butter enterprise. This matter, however, was settled for the creamery beforehand as no market could be found for the whey at ¼d. a gallon.

The operations of a Butter Factory.

The Business in 1934.

In view of the competition which farm butter has to meet and of the declining demand for this class of article producers in several regions have been attempting to evolve new methods to deal with the situation. The problem is now being tackled in two ways. In certain places the blending system has been tried with a fair degree of success. Under this plan butter from several different holdings is mixed together and in some instances imported butter is added. Variations in the original supplies are disguised and to some extent removed in the process and a more or less uniform article is obtained.

The creamery manufacture of butter from purchased milk or cream is, however, a better method as a standard article can then be attained with a fair degree of certainty. Although certain factories which obtain their raw material in the form of cream have shown successful results in recent years, those supplied with milk have in general been more satisfactory. Greater control can be exercised over the whole process, the raw material arrives in a fresh state and any unsuitable samples can be more easily detected. The temperature at which the cream is kept from the time of separating until churning can also be properly controlled under this system.

The advent of the Milk Marketing Scheme has placed farm butter-makers at an extreme disadvantage financially. Milk producers who supply butter factories command a much higher return than those who utilise the milk on the farm. The disadvantage of the farm method was, however, fairly obvious before the present "price pooling" system was adopted and many farmers were extremely dissatisfied with the situation. In 1932 producers situated in a rather isolated part of Wales decided to set up their own butter factory through a co-operative society. The first method of operation was that of collecting cream from

members and was one of experiment rather than achievement as neither the suppliers of cream nor the management committee had much experience of the work they had undertaken. It was encouraging to find, therefore, that in spite of the difficulties associated with initiation of the work, a small net profit was made during the first few months.

Cream was paid for on its butter-fat content and the price was fixed by the management committee. Three factors had to be taken into account in the financial success of the business, *viz.*, the price of butter, costs of manufacture, and the price of cream. The Committee had control over the last but very little influence over the others. An attempt was made in certain months to fix too high a price for the cream and in consequence the financial success of the business was jeopardised. With the coming of the Milk Marketing Scheme in October, 1933, the position of the cream suppliers was changed to an appreciable extent. Farmers who sold milk in liquid form qualified for the "Pool" prices and the returns to registered milk suppliers were considerably above those formerly obtainable when they disposed of their product as cream.

During 1934 the business of the factory underwent a considerable modification, increasing quantities of milk were received whilst the amount of cream taken gradually declined. There was also a persistent increase in the number of suppliers and from the beginning of the year until September the intake of milk was gradually rising. The decline in the gallonage during the last three months of the year was, of course, due to the usual

TABLE I.

Intake and Output in 1934.

1934.	*Milk Received.*	*Number of Suppliers.*	*Cream Received in lb. Butter Fat.*	*Butter Made.*
	Galls.			*lbs.*
Jan.	5,451	31	250.1	2,717
Feb.	7,293	39	90.8	8,232
Mar.	12,914	46	151.1	5,860
Apr.	27,884	94	111.8	10,935
May	44,462	103	113.6	13,126
June	55,597	136	194.5	19,923
July	59,821	151	102.1	21,309
Aug.	62,827	158	45.1	25,548
Sept.	64,153	165	20.0	25,000
Oct.	63,335	182	24.1	25,974
Nov.	51,495	194	76.6	23,486
Dec.	48,527	206	26.9	22,988
Total	503,759		1206.7	205,098

seasonal fall in production. During the early part of the year the creamery was working much below capacity and in consequence handling costs per lb. of butter were rather high.

In Table II the costs of manufacture are given separately. During the first half of the year the results appear comparatively unfavourable. Towards the summer the quantity of milk entering the factory rose at a more rapid rate than the total outlay incurred and, in consequence, there was an appreciable decline in costs per unit of product. The expenditure incurred by the factory has been allocated according to the amount of butter made in each month.

TABLE II.

Expenditure and Depreciation for Butter Production, per lb. and per cwt.

Items.	*Jan. to June.*	*July to Dec.*	*Whole Year.*	*Whole Year.*
	Pence per lb.			*Per cwt.*
				s. d.
Coal and Oil	0.13	0.12	0.12	1 1
Printing & Stationery	0.02	0.02	0.02	2
Salt and Chemicals	0.08	0.08	0.08	9
Rent, Insurance and Rates	0.09	0.04	0.05	6
Phone and Postage	0.04	0.02	0.03	3
Paper, etc.	0.08	0.08	0.08	9
Rail and Haulage	0.15	0.15	0.15	1 5
Repairs	0.07	0.04	0.05	6
Wages and Insurance	0.83	0.61	0.68	6 4
Sundries	0.02	0.02	0.02	2
Depreciation on Equipment	0.33	0.33	0.33	3 1
Total	1.84	1.51	1.61	15 0

In view of the somewhat abnormal conditions prevailing at the factory during the year the figures may not be representative of the situation in general. The number of suppliers increased from month to month, and for each farmer supplying milk in January there were six in December. Although the daily quantity of milk received fell after September the reduction was by no means as severe as would be expected had the number of suppliers remained somewhat the same throughout the year. The volume of milk supplied to the factory is likely to increase appreciably in the future, yet it is probable that there will be a rather pronounced seasonal variation in quantities.

It is probable that the factory will have to deal with appreciably heavier supplies in summer than during other seasons

and this will continue to have an important effect upon the business in general.

It is no easy matter for a new butter factory to find a suitable market for its output when the volume fluctuates unduly. There is, in fact, a slightly higher consumption of butter in Winter, when home production is low, but as compared with seasonal variations in production, both the wholesale and retail trades require comparatively even supplies throughout the year. Factories which have a considerably larger output in summer often experience some difficulty in finding buyers, especially for supplies over and above their winter offerings.

TABLE III.

The Price of Milk and Cost per lb. of Butter.

	Price of Milk per gallon.	*Gallons of Milk.*	*Cost of Manufacture.*	*Cost of Butter to Factory.*
	d.		d.	d.
Jan.	3.50	2.26	2.78	10.64
Feb.	3.25	2.26	2.51	9.85
Mar.	3.25	2.34	2.11	9.71
Apr.	3.50	2.49	1.79	10.50
May	3.50	2.47	1.74	10.38
June	3.50	2.82	1.65	11.52
July	3.75	2.74	1.62	11.89
Aug.	4.00	2.46	1.45	11.29
Sept.	4.00	2.56	1.47	11.71
Oct.	3.72	2.44	1.44	10.51
Nov.	4.04	2.19	1.54	10.38
Dec.	4.25	2.11	1.56	10.52
Average	3.61	2.51	1.61	10.67

The cost of the butter to the factory is dependent upon three factors, *viz.*, the price of milk, the amount of milk used per lb. of butter and the expenses of manufacture. In consequence of the natural variation in the fat content of milk, the quantity necessary to make a pound of butter fluctuates from one month to another, but on the average it has amounted to 2.51 gallons. The total cost of the butter to the factory for the year amounted to 10.67d. a lb. whereas the average price realised for the butter was only 9.57d. a lb. Although an appreciable quantity was sold on the retail market at a comparatively satisfactory price the bulk was sold at wholesale rates and in the summer of 1934 prices were rather low. The society, however, obtains part of its income from the re-sale of skim milk to the suppliers of fresh milk.

The financial transactions of the creamery per lb. of butter can be set out as follows :—

	Pence per lb.
Sales of Butter	9.57
Sales of Skim Milk	3.29
Total Income	12.86
Cost of milk, materials, labour, etc.	10.67
Net Profit	2.19

Although the manufacture of butter for sale at the wholesale prices ruling at the time was not a profitable proposition, the creamery was able to show a substantial net profit as receipts from skim milk more than offset the loss.

The Business in 1935.

The increase in the number of suppliers and in the quantity of milk received, which has been such a conspicuous feature of the business since its commencement, continued throughout 1935. Milk is now being sent from farms in comparatively isolated places where, until recently, farm butter production had been the established system. With the widening of the zone of supply, costs of collection tend to rise, and it is becoming increasingly difficult to arrange suitable times of delivery to meet the requirements of the factory. The society must in future consider the problem of opening separating stations to deal with supplies obtained from distant centres. Certain economies will undoubtedly be effected by this policy, the collection costs of milk would be reduced whilst it would be possible to deal with skim more readily. Under such conditions many farmers would undertake to convey their own milk to the depot and collect supplies of skim.

The intake of milk was at its maximum in June; in subsequent months there was a decline, and the December total only amounted to 61 per cent. of the June figure. In view of the fact that the number of suppliers increased by 24 per cent. during the last six months of the year the quantity of milk available in the autumn was prevented from falling to the low level resulting from seasonal production of milk. The policy of drawing milk from more distant areas and from new suppliers must be followed with care. New suppliers are almost invariably unaccustomed to the management of a dairy herd from which the milk is sold in liquid form. The majority are anxious to dispose of their milk to the creamery in the summer months but are extremely reluctant to undertake the provision of a fairly even supply throughout the

year. Under such conditions costs of production per lb. of butter are likely to be unduly high in the winter.

TABLE IV.

Intake and Output in 1935.

1935.	*Milk Received.*	*Number of Suppliers.*	*Cream Received = 1 lb. Butter Fat.*	*Butter Made.*
	Galls.		*lb.*	*lb.*
Jan.	53,259	220	24.4	23,065
Feb.	61,205	249	10.7	24,672
Mar.	85,271	254	10.0	32,549
Apr.	101,371	257	10.6	38,423
May	135,284	260	316.6	50,257
June	142,005	260	178.7	56,271
July	140,262	266	108.3	56,292
Aug.	126,533	268	255.8	53,527
Sept.	105,678	268	13.3	45,654
Oct.	100,322	288	20.0	45,950
Nov.	86,078	313	17.5	41,061
Dec.	87,373	324	—	40,327
Total	1,224,641	—	965.9	508,048

During the earlier part of 1934 the costs of manufacture, per lb. of butter, declined with the expansion in the business of the society. The rate of decline, however, especially during the latter half of the year, was far less rapid than the rate of increase in the quantity of butter made and towards the close of the year the costs remained almost unchanged. During 1935 the quantity of butter made in each month was considerably in excess of that made in the corresponding months of the previous year, on the whole the increase amounted to 147 per cent. While there were considerable variations in monthly quantities made during 1935 the fluctuations in the costs of manufacture were relatively small, and the average for the year stood at 1¼d. a lb. Decreasing costs per unit of product with the expansion in the size of the business have been very conspicuous, but it is doubtful whether a further significant decline will follow an increase in the volume of product handled. The quantities of raw materials used will vary directly with the amount of butter made; the quantity of butter which each employee can handle properly is also limited, and as additional quantities could only be dealt with by an increase of staff it is unlikely that labour costs per lb. will show any considerable decline.

The financial results of the business were considerably more favourable for 1935 than for 1934. The price of the milk to the

factory, however, was slightly higher, especially during the earlier part of the year.

The returns from butter on the whole showed an improvement as the general level of prices hardened somewhat towards the latter part of the year. The rise in the prices realised for butter, however, was mainly due to the fact that the society was able to dispose of increasing quantities on the retail market. Most manufacturing businesses experience some difficulty in finding markets for their products during the first few years of operations and the factory was no exception. During 1933 and 1934 large quantities of butter had to be sold at particularly low prices in order to attract buyers. Customers had to be obtained and kept. The factory succeeded to a very marked degree in attaining its objective. A large number of new buyers were obtained as the butter proved satisfactory to consumers. During

TABLE V.

Expenditure and Depreciation for Butter Production per lb. and per cwt.

	Jan. to June.	*July to Dec.*	*Whole Year.*	*Whole Year.*
	Pence per lb.			*Per cwt.*
				s. d.
Coal and Oil	0.12	0.11	0.11	1 0
Printing & Stationery	0.01	0.01	0.01	1
Salt and Chemicals	0.05	0.05	0.05	6
Rent, Insurance and Rates	0.02	0.02	0.02	2
Phone and Postage	0.02	0.01	0.02	2
Paper, etc.	0.13	0.13	0.13	1 3
Rail and Haulage	0.12	0.12	0.12	1 1
Repairs	0.15	0.13	0.14	1 4
Wages and Insurance	0.46	0.44	0.45	4 3
Sundries	0.11	0.11	0.11	1 0
Depreciation on Equipment	0.10	0.08	0.09	10
Total	1.29	1.21	1.25	11 8

1935 the business was, therefore, able to reap a good deal of benefit from its earlier policy. Markets were found with greater ease and the price could be raised somewhat without discouraging established buyers. With the increasing output of the factory, however, fair quantities have still to be offered at somewhat low prices, especially in those regions into which the society is attempting to penetrate. As long as the business continues to expand a continually widening market must be found and in consequence a certain amount of butter must be sold at keenly competitive prices.

TABLE VI.
The Price of Milk and Cost per lb. of Butter.

	Price of Milk per Gallon.	Gallons of Milk.	Cost of Manufacture.	Cost of Butter to Factory.
	d.	per lb. Butter.	d.	d.
Jan.	3.98	2.31	1.64	10.71
Feb.	4.28	2.48	1.63	12.12
Mar.	4.19	2.62	1.48	12.40
Apr.	4.18	2.63	1.30	12.29
May	4.26	2.71	1.12	12.66
June	4.04	2.58	1.06	11.28
July	4.00	2.49	1.10	11.06
Aug.	3.79	2.38	1.18	10.15
Sept.	3.93	2.31	1.23	10.30
Oct.	3.75	2.18	1.23	9.40
Nov.	3.75	2.09	1.31	9.14
Dec.	3.75	2.16	1.32	9.42
Average	4.01	2.41	1.25	10.91

The financial transactions of the society can be briefly stated as follows :—

	Pence per lb.
Receipts from Butter	10.30
Receipts from Skim Milk	2.82
Cost of milk, labour, materials, etc.	10.91
Net Profit	2.21

Although the average price of butter was higher than in 1934 by over one halfpenny a lb. the butter making enterprise failed to show a profit. The cost of milk alone amounted to 9.6d., or only .7d. below the price realised per lb. of butter. The cost of manufacture at 1¼d. a lb. showed a slight drop on the previous year and has been falling to as low a figure as can be expected at a factory of this size. Receipts from skim milk were a little lower per lb. of butter made, as during several months in 1935 the prices were below those of the previous year. The work of the year has been quite successful, but it is clear that at present prices of milk and butter great care has to be exercised in the treatment of the main product, as it is upon the revenue that it yields that the financial success of the business depends.

This factory, at least within its areas, has solved the problem of ensuring the manufacture of good butter, together with ensuring the return of good separated milk to the farms for stock-rearing purposes. Where factory butter has to be made regularly the system adopted by this factory makes the most economical use of milk and the least necessary disturbance of the general system of farming.

COSTS OF FATTENING CATTLE

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Owing to the absence of detailed information of costs of beef production under general farming conditions it was decided, in October 1934, to secure the co-operation of a small number of farmers with a view to testing out a method of collecting the essential data. Eight farmers forwarded information during the winter six months (October 1, 1934, to March 31, 1935) while five continued to co-operate during the following summer six months. The method has been proven and the results are sufficiently interesting to justify a general statement.

This study is confined to the results of the five records complete for one year and is concerned with 735 animals fattened or fattening. The following table sets out the essential information relating to average values and weights per animal.

TABLE I.

Cattle Input and Output.
(Average Values and Weights).

	No.	*Total Value.* £ s. d.	*Average Value.* £ s. d.	*Total Weight.* cwt.	*Average Weight.* cwt.
Opening Valuation	214	3441 0 0	16 1 9	1881.75	8.79
Store Cattle purchased or transferred in	521	6651 17 6	12 15 4	3848.25	7.39
Total Intake	735	10092 17 6	13 14 8	5730.00	7.80
Total Cattle Sold	513	9091 19 6	17 13 8	5153.00	10.04
Beef Subsidy	513	1255 1 10	2 8 11	—	—
Sales and Subsidy	513	10327 1 4	20 2 7	5153.00	10.04
Closing Valuation	222	3638 16 0	16 17 10	2024.00	9.12
Sales, subsidy and on hand	735	13965 17 4	19 0 0	7177.00	9.76
Difference between Input and Output	735	3872 19 10	5 5 4	1447.00	—

Of the 735 animals 391 were bullocks, 328 were heifers and sixteen were cows. The bulk of the bullocks and heifers were purchased for fattening, but the cows were drafted from milking or rearing herds.

The average value of the cattle fattening at the beginning of the investigation was £16 1s. 9d., and the average value of

stores and old cows subsequently purchased or transferred in for fattening was £12 15s. 4d. The fat cattle sold realised an average value of £17 18s. 8d. without and £20 2s. 7d. with the subsidy. The estimated average value of cattle fattening at the end of the year was £16 17s. 10d., or about 16s. higher than the figure for those fattening at the beginning. The average values for the three classes of animals were as follows :—

TABLE II.

Average values or Prices of Stores and Average Market Price of Fat Cattle, excluding the Beef Subsidy.

	Store Cattle.	*Fat Cattle.*
	£ s. d.	£ s. d.
Bullocks	13 7 2	19 0 5
Heifers	12 4 10	16 8 1
Cows	10 15 6	14 12 5
Average	12 15 4	17 18 8

In general these farmers aimed at producing a uniform number of fat cattle each month. During the winter six months 300 stores and barreners were brought into the fattening yards. and 275 fat animals were sold. In the succeeding summer six months the relative figures were 221 and 288 respectively. September was the only month in which no stores were purchased or transferred for fattening. During the three months February to April, 260 store bullocks and heifers were introduced into the fattening herds, comprising nearly 50 per cent. of the total during the year. Smaller purchases or transferences were made during the months of October to January and were limited to the minimum number required for disposal during April, May and June. The number of fat cattle sold each month ranged from fifteen to sixty-one animals, but for seven months the range was from forty to sixty-one, and for five months show a range of from thirty-one to thirty-nine animals.

The total amount received from the beef subsidy was £1,255 1s. 10d., of which £677 18s. 2d. was obtained during the winter and £577 8s. 8d. during the summer six months. The ten cows sold fat were not eligible for subsidy payment and the average amount received for the remaining 501 cattle sold was £2 10s. 1d. The average market price plus subsidy for the bullocks and heifers was £20 5s. 8d. The increase in the value of the cattle fattened or fattening amounted to £2,617 18s. 0d.

or £3,872 19s. 10d. when the subsidy was included. The relative figures for the winter and summer periods were :—

TABLE III.

Increase in Value of Fattening Cattle.

	Winter.	*Summer.*	*Total.*
	£ s. d.	£ s. d.	£ s. d.
Value, excluding Beef Subsidy	1,308 19 10	1,382 18 2	2,617 18 0
Beef Subsidy	677 13 2	577 8 8	1,255 1 10
Total	1,986 13 0	1,886 6 10	3,872 19 10

The estimated production of beef during the year was 1,447 cwt., of which 696.5 cwt. was produced during the winter and 750.5 during the summer months. The average weight of the cattle fattening at the begining of the year was 8.79 cwt., stores purchased or transferred in for fattening averaged 7.39 cwt., fat cattle sold averaged 10.04 cwt., and fattening cattle at the end of the year averaged 9.12 cwt. Both store and fat cattle were heavier in the winter than in the summer months. The following summary shows the average weights of store and fat cattle.

TABLE IV.

Average Weights of Fat and Store Cattle.

	Summer.	*Winter.*	*Total.*
	cwt.	*cwt.*	*cwt.*
Average weight of Fat Cattle	10 27	9.78	10.04
Average weight of Store Cattle	7.58	7.13	7.39
Difference	2.69	2.65	2.65

Margins between store and fat cattle weights were greatest for bullocks, the figures being 3.39 cwt. for the winter and 2.98 cwt. for the summer six months.

The number of cattle fattening at the end of the period, their average weight and value, were higher than at the beginning and therefore the net number raised from store to fat cattle condition would be higher than the number sold. Assuming that the increase in the market value of all animals raised from store to fat condition would be the same as that between store and fat cattle prices shown in Table I, namely, £4 18s. 4d., then the net number of animals fattened would be about 588. This figure

may be taken as being fairly accurate and has been used in the determination of feeding costs per animal fattened.

The total costs of feeding amounted to £2,664 15s. 8d., and the marketing costs to £178 11s. 9d., making a total of £2,843 7s. 0d. The total cost of feeding and marketing exceeded the increase in the market value of the cattle fattened by £225 9s. 0d., but with the subsidy payments there was a balance of returns over costs of £1,029 12s. 10d. A detailed statement of the feeding costs is given in Table V.

Using the figure of 588 for cattle fattened during the year the net cost per animal amounted to £5. The average cost per estimated cwt. of beef produced was £1 16s. 10d., while the comparable figures for the winter and summer feeding periods were £2 6s. 9d. and £1 7s. 7d. respectively. The cost over the whole year amounted to 7.08d. per fattening day, while for the winter

TABLE V.

Yearly Average Costs of Beef Production.

	Cost per estimated animal fattened.	*Cost per cwt. of Beef produced.*	*Cost per fattening day.*	*Per cent. of total cost.*
	£ s. d.	£ s. d.	d.	per cent.
Purchased Foods:				
Concentrates	2 5 11	16 11	3.26	45.92
Beet Pulp	10	4	0.06	0.87
Condiments	1			0.06
Total Purchased Foods	2 6 10	17 3	3.32	46.85
Home-grown Foods and Litter:				
Concentrates	2 7	11	0.18	2.58
Hay	1 0 3	7 6	1.43	20.21
Roots	2 9	1 0	0.20	2.77
Straw	1 11	9	0.14	1.97
Grazing	17 7	6 6	1.24	17.57
Total Home-grown Foods and Litter	2 5 1	16 8	3.19	45.10
Gross cost of Foods and Litter	4 11 11	1 13 11	6.51	91.95
Deduct Manurial Residues	6 0	2 3	0.43	6.02
Net cost of Foods and Litter	4 5 11	1 11 8	6.08	85.93
Labour on feeding	10 6	3 10	0.74	10.48
Rent of Buildings	8 2	1 2	0.23	3.21
Depreciation on equipment	3	1	0.01	0.22
Vet. and medicines	2	1	0.02	0.16
Total net costs of Production	5 0 0	1 16 10	7.08	100.00

period it was 11.20d., and for the summer period 4.49d. per fattening day.

In determining the net costs of feeding the manurial residues have been deducted from all foods (excluding grazing) and charged to the farmyard manure account or to the grassland in the case of concentrates fed to grazing cattle. This deduction amounted to 6s. per animal fattened.

Purchased foods represented about 47 per cent. and home grown foods, including grazing and litter, about 45 per cent. of the total gross cost.

The following statement shows that the cost per cwt. of beef produced was 19s. 2d. more in the winter than in the summer period.

TABLE VI.

Costs of Beef Production for the Winter and Summer Periods.

	Winter.			*Summer.*		
	Cost per cwt. of Beef Produced.	*Cost per Fattening day.*	*Per cent. of Total Costs.*	*Cost per cwt. of Beef Produced.*	*Cost per Fattening day.*	*Per cent. of Total Costs.*
	£ s. d.	d.	%	£ s. d.	d.	%
Purchased Foods	1 2 3	5.32	47.51	12 8	2.06	45.80
Home Grown Foods	1 0 7	4.93	44.03	12 11	2.10	46.79
All Foods	2 2 10	10.25	91.54	1 5 7	4.16	92.59
Deduct Manurial Residues	3 2	0.75	6.71	1 4	0.22	4.95
Net Costs of Foods	1 19 8	9.50	84.83	1 4 3	3.94	87.64
Other Costs	7 1	1.70	15.17	3 4	0.55	12.36
Total Net Costs of Production	2 6 9	11.20	100.00	1 7 7	4.49	100.00

Purchased foods show little variation in their importance during the two fattening periods. The bulk of the food purchased consisted of compound cakes and meals and maize products, and although a greater proportion of the more expensive compound foods was purchased in the summer the average price per ton for all foods was about 10s. less than that for the winter period. The daily consumption of concentrates amounted to 7.09 lb. per head for the winter and 2.74 lb. for the summer, this being equivalent to 355 lb. of concentrates per cwt. increase in the former and 172 lb. in the latter period. None of the grassland was good

enough to fatten cattle without the aid of some concentrates, and the grass plus 2.74 lb. of concentrate gave an increase in liveweight of only 1.52 lb. as against a daily increase of 2.28 lb. during the winter. The mean daily increase in liveweight over the two periods was 1.79 lb.

The cost of marketing was 7s. 8d. per animal sold. This includes transport and insurance charges, market tolls and auctioneer's commission, together with charges for grading.

Of the eight records for the winter fattening only two showed profits, while all the five records for summer fattening showed a favourable balance. The general position for the five records is given in the following summary.

Profits and Losses for the Winter and Summer Fattening Periods and for the Year.

	Winter. *No.*	*Summer.* *No.*	*Whole Year.* *No.*
Losses	3	—	1
Profits	2	5	4

One of the farmers, whose accounts showed a loss in the winter period, did not obtain a profit during the summer large enough to balance the loss, and his account for the year showed an unfavourable balance. The enterprises as a whole showed a profit in both periods; for the winter period it amounted to £265 10s. 4d. or £53 2s. 1d. per farm, and for the summer £764 2s. 6d. or £152 8s. 6d. per farm.

The summary below shows the margin between store and fat cattle prices, together with the cost of fattening and marketing.

Store and Fat Cattle Price Margins and Feeding Costs.

	£	s.	d.
Average Market Value of Fat Cattle	17	13	8
Average Market Value of Store Cattle	12	15	4
Margin	4	18	4
Beef Subsidy per Animal sold	2	8	11
Margin with Subsidy	7	7	3
Cost of Fattening per Animal	5	0	0
Cost of Marketing		7	8
Cost of Production and Marketing	5	7	8
Profit per estimated animal fattened	2	0	0

These results show that without the beef subsidy cattle fattening would have shown a loss of about 9s. per animal. The average profit per animal fattened was about 8s. 11d. less than

the subsidy received per animal sold and 10s. 1d. less than the subsidy per graded animal.

The indices of store cattle prices showed an improvement during the year covered by these records, the mean for the summer being four points higher than that for the winter. In the case of market prices of fat cattle there was a fall of about four points and a fall of two points when account is taken of the subsidy payments. The industry as a whole showed a slight improvement; the mean of the monthly indices being one point higher for the summer than for the winter. The records showed higher values per cwt. in the summer period for both store and fat cattle.

Value per cwt. of Store and Fat Cattle and Cost of Production and Marketing.

	Winter.	*Summer.*	*Year.*
	£ s. d.	£ s. d.	£ s. d.
Store Cattle	1 13 7	1 16 0	1 14 7
Fat Cattle (Market Price)	1 14 7	1 15 11	1 15 3
Beef Subsidy	4 10	5 0	4 10
Market Price and Subsidy	1 19 5	2 0 11	2 0 1
Costs of Production	2 6 9	1 7 7	1 16 10
Marketing	8	8	8
Cost of Production and Marketing	2 7 5	1 8 3	1 17 6

The higher value per cwt. for stores during the summer six months suggests that the subsidy payment for graded fat cattle has tended to lift the value per cwt. of stores above the market price per cwt. for graded animals.

The production and marketing cost for the winter was 19s. 2d. per cwt. increase in liveweight above that for the summer. During the winter the cost per cwt. was 8s. higher, and in the summer 12s. 8d. lower than the selling plus subsidy values. The average selling price of fat cattle for the year was 2s. 8d. per cwt. below the production and marketing costs. But all store cattle purchased at about £1 15s. 0d. per cwt. have a potential market plus subsidy value of nearly £2 per cwt. Thus a 7.5 cwt. store purchased at £1 15s. 0d. per cwt. brings to the feeder an additional potential value of nearly 5s. per cwt., and this is realised when the animal is certified and sold.

Thus in a particular case where the animal is fattened to 10 cwt. and sold at 35s. the final position would be as follows :—

	£	s.	d.
7.5 cwt. Store animal @ 35/- per cwt.	18	2	6
10.0 ,, Fat animal @ 35/- per cwt.	17	10	0
Subsidy @ 4/10 per cwt.	2	8	4
	19	18	4
Margin	6	15	10
Production and Marketing Costs @ 37/6 per cwt.	4	13	9
	£2	2	1

The indications are that small profits were made by feeders in the year 1934-35 but more in the summer than in the winter period, and always on the basis of very low prices for stores. With an average price of less than 35s. per cwt. it is extremely doubtful whether adequate supplies of stores will continue, and with any appreciable rise in prices of stores at least equal increases in prices for fat cattle must occur if feeders are to obtain even small profits as in the last year.

THE LAMB FATTENING CAPACITY OF CERTAIN CROPS FOR HILL CONDITIONS.

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The smallness of the Welsh hill farmer's income can be attributed, in the main, to two factors—the necessity for wintering away a considerable proportion of his flock and the inability of his mountain grazings to fatten lambs. The former entails a large expenditure and the latter necessitates the drafting out of his better wether lambs for sale at store prices to lowland farmers. When the Cahn Hill Improvement Scheme commenced work in 1933 it was found necessary to deviate from established practice both in order to minimise as far as possible the losses from these two sources and, at the same time, to establish other improvements in the system of management of hill flocks. The provision of winter keep has been dealt with elsewhere (1 and 2).

and the present article is concerned solely with lamb fattening under hill conditions.

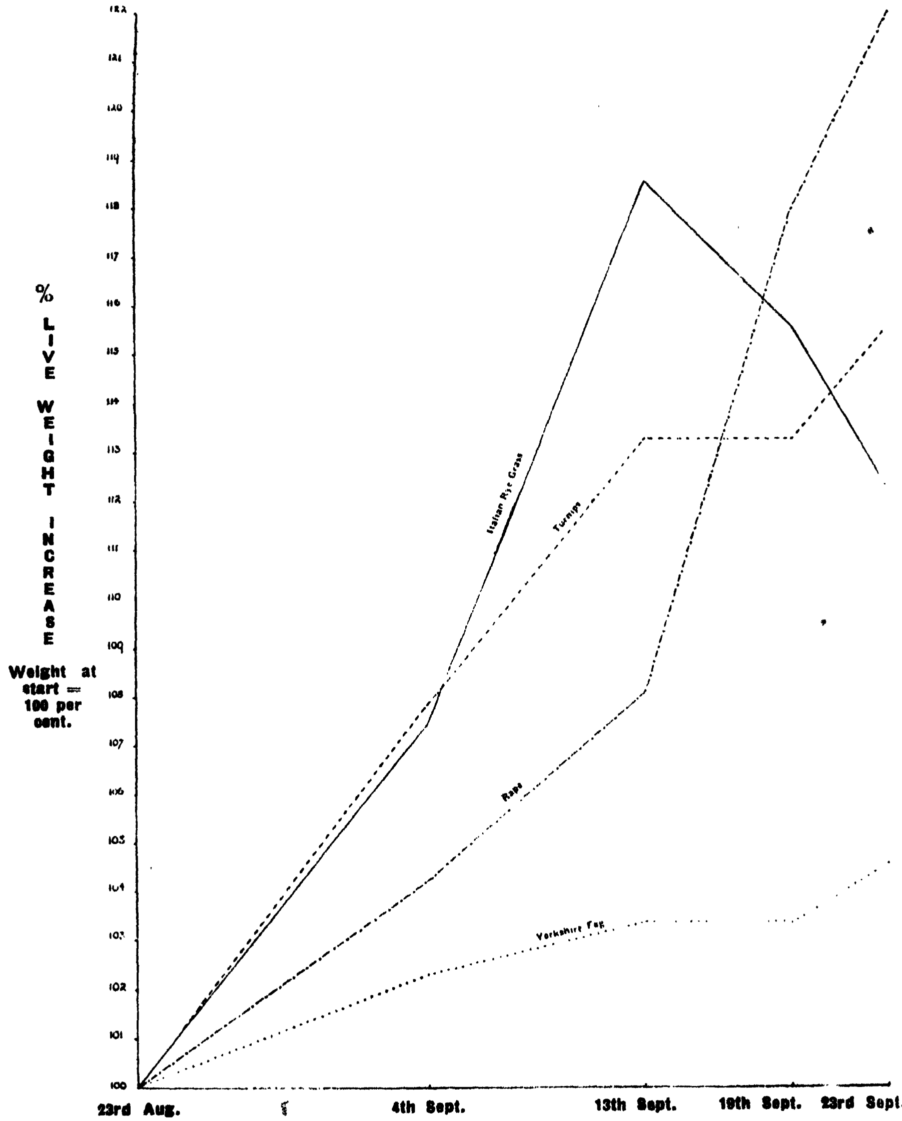
The initial step in the improvement of tracts of fenced hill land is the taking of two or three fattening crops consisting of one or more crucifers sown together with temporary grasses, which latter will also provide a considerable amount of winter keep. It was in order to test the value of some of these crops that the following experiment was laid out. A field of south-westerly aspect, very exposed to the prevailing winds, about two-and-a-half acres in size and varying in altitude from 890 to 930 feet above sea level, was chosen for the experiment. This field had been sown down to grass in 1925 after having been put through a four-course rotation. It was ploughed up in February, 1934, and sown down in a series of experimental oat plots, receiving a uniform manurial dressing of six cwt. per acre basic slag (32 per cent.), applied in April, and one cwt. per acre nitro-chalk applied in May. The stubble was ploughed up in mid-December, harrowed down in late spring and sown down on May 31, 1935. The field was divided into four plots of approximately 2,940 square yards each in size. After sowing, the plots were fenced round with pig netting. The rate of seeding was as follows :—

Plot No.	*Seed.*	*Lb. per acre.*
1.	Rape	6.5
2.	Hardy green turnips	4.0
3.	Italian rye-grass	28.0
4.	Yorkshire fog	21.0

At the end of July the plots were top dressed with one cwt. per acre C.C.F. No. 4, and grazing with lambs commenced on August 28. The selected lambs were drawn from a batch of wether lambs from the mountain sheep walk and were grouped into four lots of twenty lambs each. Size, type and thriftiness were taken into consideration in making the four lots as even as possible. The average deviation was 0.62 lb. and the maximum deviation of any one lot two lb. Twenty lambs were turned on to each plot, where they remained until September 28; they were weighed at intervals throughout the period and the results of these weighings are shown in Table I. These results are also shown graphically on a basis of percentage live weight increase in Graph No. 1.

GRAPH I.

Graph to show the average live weight increase of four groups of twenty lambs each, fattened on various crops during the period 23rd of August —23rd of September, 1935.



In any interpretation of the above figures, weather conditions prevailing during the course of the experiment are of the greatest importance. Rain fell on twenty-one days during the course of the experiment, very heavy rain being experienced during the latter half of the period. Such conditions would be expected to retard very seriously the rate of fattening. The

maximum increase in weight, 9.5 lb., was produced by the rape plot, and the maximum increase, 2 lb., by the Yorkshire fog plot. Intermediately the turnip plot showed an increase of 7 lb.

TABLE I.

Date.	*Live weight in lb., average per lamb per plot.*			
	Rape.	*Turnips.*	*Italian R.G.*	*Yorkshire fog.*
23/8/35	43.00	45.00	43.00	43.50
4/9/35	44.80	48.50	46.20	44.50
13/9/35	46.50	51.00	51.00	45.00
19/9/35	50.75	51.00	49.70	45.00
23/9/35	52.50	52.00	48.80	45.50

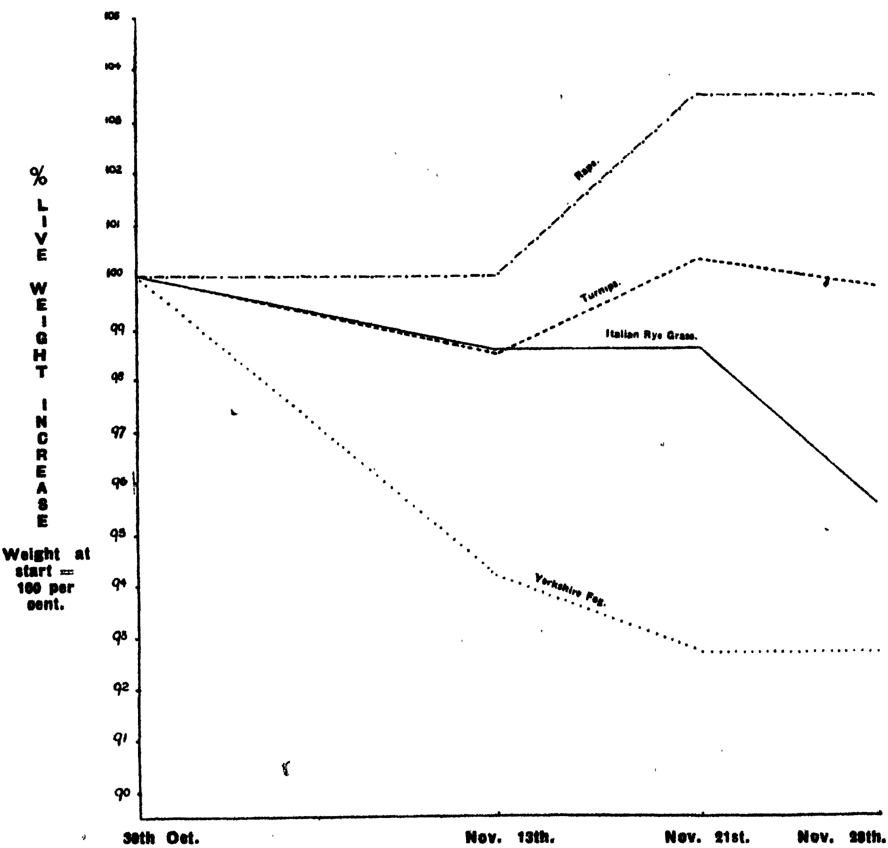
and the Italian rye-grass one of 5.8 lb. In the case of the Italian rye-grass it should be noted that the initial fattening rate was more rapid than that produced by any other crop, but during the latter part of the experiment there was a considerable loss of weight, though to all outward appearances there was plenty of keep on the plot. The graph of the turnip plot shows a rapid initial increase, followed by a stationary period and, finally, a further rapid increase. On the other hand, the rape plot started more slowly, the lambs not seeming to take readily to it; however, as the lambs became accustomed to the crop their increase was rapid and maintained right to the end of the experiment. The rate of increase on the Yorkshire fog plot was very slow, but was maintained fairly steadily throughout the course of the experiment. At the conclusion of the experiment forty-seven of the eighty lambs were considered ready for despatch to the Manchester Abbattoirs under the Ministry of Agriculture's grading scheme. The forty-seven lambs were drawn from the four plots in the following numbers :—Rape, sixteen; turnips, seventeen; Italian rye-grass, ten; Yorkshire fog, four.

Under hill conditions the fattening of lambs after October is considered to be a very slow process, the lambs rarely putting on any appreciable weight until the following spring. In order to acquire information about this contention it was decided to graze the aftermath of the four plots after a rest period had been allowed. At the conclusion of the first experiment there was a considerable amount of keep remaining on all four plots, enough, in all probability, to have lasted the lambs for a further ten days. However, in order to obviate any possibility of shortage of keep, it was decided to rest the plots then for a few weeks, and during this time one cwt. per acre of nitro-chalk was applied.

On October 30 there was a fair growth on all four plots and ten lambs were turned on to each plot. The lambs were selected on the same principles as those employed in choosing the groups for the first experiment. The average deviation was 0.575 lb. and the maximum deviation of any one lot 2.1 lb. The lambs remained on the plots until November 28, when shortage of keep necessitated their removal; they were weighed at intervals during this period and the weighings are given in Table II. They are also shown graphically on the basis of percentage increase or decrease in live weight on Graph 2.

GRAPH II.

Graph to show the average live weight increase or decrease of four groups of ten lambs each, fattened on various crops during the period 30th of October—28th of November, 1935.



The weather during the period was extremely unfavourable, inasmuch as rain, usually accompanied by driving wind, fell on twenty-three days out of the thirty. Rape was the only plot to produce an increase; the turnip plot, after an initial loss, showed

a small gain, only to fall away again in the final stages. For the greater part of the period the lambs on the Italian rye-grass plot retained their weight, but as in the first experiment, suffered a

TABLE II.

Date.	*Live weight in lb., average per lamb per plot.*			
	Rape.	*Turnips.*	*Italian R.G.*	*Yorkshire fog.*
30/10/35	48.30	47.60	49.70	48.30
13/11/35	48.30	46.90	49.00	45.50
21/11/35	50.00	47.75	49.00	44.75
28/11/35	50.00	47.50	47.50	44.75

sharp setback in the closing stages. The Yorkshire fog group showed a heavy drop, though the rate of drop decreased as the experiment progressed. Whilst rape showed a gain of 1.7 lb. per lamb, turnips, Italian rye-grass and Yorkshire fog showed losses of 0.1 lb., 2.2 and 3.55 lb. per lamb respectively.

The experiment is open to criticism on the ground that the plots were not replicated; it should, however, be borne in mind that there were twenty lambs on each plot. The results do not permit any dogmatic conclusions to be drawn, but, coupled with actual observation, they indicate that the cruciferous crops tested are superior in fattening capacity to the grasses, rape giving a somewhat better return than hardy green turnips. Of the two grasses, Italian rye-grass has proved to be far the better in fattening capacity, and in this connection it must also be remembered that Italian rye-grass has a considerable value as winter keep, lambs rationed on it during the winter and early spring doing exceptionally well. On the other hand, Yorkshire fog, besides being far inferior in fattening capacity to Italian rye-grass, is of much less value as winter keep. It follows, therefore, that Yorkshire fog should only be included in quite short duration mixtures on land that is incapable of producing a satisfactory stand of Italian rye-grass.

Acknowledgments.

We desire to express our thanks to Professor Stapledon, C.B.E., M.A., for his help in drawing up the plan of the experiment and for his helpful advice and criticism. Thanks are also due to Mr. D. M. Pole-Evans for valuable assistance throughout the course of the experiment.

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THE WINTERING OF SHEEP ON TEMPORARY GRASSES.—*Continued.*

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The following notes bear further reference to the wintering of lambs on timothy grass grown in rows on the system described by the same writers in a previous article. In May, 1933, seven acres of land approximately 850 feet above sea level were drilled in rows 18 in. apart with pedigree indigenous timothy bred at the Welsh Plant Breeding Station. In October the most forward portions were run over lightly with the mower and the produce converted into A.I.V. silage. Grazing commenced on November 12, when ninety-one lambs were turned into the rows for two hours daily from an old pasture of ten acres on which they spent the remainder of the twenty-four hours. The lambs continued grazing on this principle until February 12, and the rows were then rested until March 5. At this date 120 weakly ewes brought down from the mountain sheep-walk were given the run of the rows, together with the old pasture for a period of six weeks (1).

In July, 1934, a hay crop of excellent quality, yielding about one ton to the acre, was taken off the rows and a dressing of one cwt. per acre C.C.F. No. 4 was applied. In the winter of 1933-4 the lambs had been turned to the rows immediately after they were drafted from the hill, but in the winter now under review, namely, 1934-5, the lambs were kept in an enclosed paddock on the hill until December 5, when grazing commenced on the timothy rows. Ninety-eight lambs were again turned to the old ten-acre pasture adjoining, and were given daily access for a period of two hours to the timothy. The lambs continued grazing on this system until March 15, and

weighings were made at intervals. The results of the weighings are given below :—

Date.	*Average weight per lamb in lb.*
5/12/84	85.0
19/12/84	86.0
6/1/85	87.0
81/1/85	84.0
18/2/85	88.6
27/2/85	84.0
15/8/85	85.5

At the end of the wintering period, although the lambs had not increased appreciably in weight, they had grown considerably and had the appearance of being in good thrifty condition.

The lamb grazing amounted to 9,800 grazing days (one grazing day equals one sheep or yearling on the area for twenty-four hours). The rows were then rested until April 15, when forty-two weakly ewes were turned in to graze there until May 6. These ewes had free access from the pasture to the timothy for the whole of the twenty-four hours. This amounts to 882 grazing days.

In August, 1985, after another good hay crop had been taken, 208 fattening lambs were turned on to the area for fourteen days. Adjoining the existing rows a new area of timothy had been drilled, and the primary purpose of this lamb grazing was to eat down the mustard that had been sown with the grass to serve as an indicator. The lambs, however, spent a great deal of the time on the old rows, and it is considered a fair allowance to credit one half of the grazing days to the old rows. This is equivalent to 728 grazing days on the old rows. (One sheep day equals two lamb days).

During a six-week period commencing in mid-March, cattle and horses grazed on the rows to an equivalent joint total of 1,872 grazing days.

This gives a total of grazing days for the area as follows :—

Sheep (winter)	10682
Sheep (summer)	728
Cattle and horses	1372
	12782

This total of 12,782 for the timothy rows (plus the old pasture in winter only), compares with 13,821 grazing days given by the same areas in the winter of 1988-4, in which year no horses or cattle were grazed on the rows in winter or spring. Thus it will be seen that the total grazing days for 1988-4 winter exceed those for the 1984-5 winter by 1,267, but, if the extra summer

grazing obtained in the latter summer be taken into account the difference is reduced to 589 grazing days.

The principal difficulty encountered in this system of wintering is that caused by the necessity for inter-row cultivation. (Experience with timothy in Wales has shown that when broadcast in pure plots the resulting sward is very apt to become weed-infested (2)). The consolidation of the ground resulting from the treading of the sheep makes inter-row cultivation extremely laborious and the ideal implement for the work, in fact the only implement to be at all satisfactory, especially on heavy ground is the rototiller. A horse hoe is of little use on the hardened ground, and a plough was tried but proved unsatisfactory on account of the soil being turned over to rest on the top of the young grass. This necessitated heavy harrowing to clear away the clods and, even then, such clods as remained were sufficient to cause considerable trouble to the mower when the area was cut for hay.

In mid-Wales about the third week in October is the customary time for sending lambs down to their wintering grounds. This practice no doubt assists both in bone formation and in the addition of a certain amount of extra fat before the cold weather commences. On the other hand it is a well founded belief that if lambs are done too well at this period the losses attributable to braxy and similar diseases are likely to be heavier than otherwise would have been the case. In the winter 1934-5 the lambs were kept on the hill until early December, and quite a strong case can be made out for keeping them there for even a few weeks longer, the critical period being in the first four months of the year. The adoption of such a system would be beneficial in two ways. Firstly, the timothy would have made a certain amount of additional growth during early winter and, secondly, the grass that would have been eaten normally in November and December would be available for March and April and the benefit, *pro rata* to the sheep, of such grass would be increased considerably.

It is a debatable point among hill farmers as to whether lambs should be wintered on really first-class or on second quality pastures; some even going so far as to maintain that lambs which have subsequently to live on high and exposed mountain sheep-walks will, on reaching maturity, do much better if wintered at fairly high elevations on third quality pastures, provided always that a proportion of that pasture is in its first or second year. This contention would seem to imply that lambs would thrive better subsequently if wintered under fairly hard

conditions, provided that they are allowed access to a proportion of mineral efficient herbage. The results so far obtained by the Cahn Hill Improvement Scheme from such a system of wintering tend rather to confirm this view. The lambs wintered on the rows during 1933-4 were tatooed and turned to graze on the open-hill together with the lambs wintered on the lowlands. The subsequent progress of the "row" lambs has been at least as good as that of the lowland lambs, though, from observation alone, it cannot, however, be said that they have done any better. In comparison with these a similar lot of lambs was wintered on a sixty-acre block, of which thirty acres had been improved during the previous summer, the bulk of the winter available herbage on the new area being composed of Yorkshire fog. By the middle of March a great difference was noticeable in the appearance of the lambs. The batch wintered on the timothy showed a slight increase in weight and were in thrifty condition, whereas those wintered on the fog had lost over three pounds per head in weight and were not so sharp and active as, nor had they the thrifty appearance of, the lambs wintered on the timothy rows. The difference can be attributed largely to two factors. Firstly, a daily ration of mineral efficient timothy grass as against a more or less burnt and partly dried up fog pasture and, secondly, the difference in elevation, the timothy lambs grazed at an elevation of 850 feet and those on the fog at one varying from 1,100 and 1,300 feet above sea level.

On February 5, 1936, samples of each of the following grasses were cut and chemically analysed by Professor Fagan: (*a*) Yorkshire fog from the area mentioned in the previous paragraph, (*b*) timothy from the row field, and (*c*) Italian rye-grass which had been sown in May, 1935, under oats for winter keep. From the analysis it was shown that Yorkshire fog contained only about 20 per cent. of the phosphoric acid and less than 50 per cent. of the lime that was contained in the timothy and Italian rye-grass.

The whole problem of wintering hill lambs is very intricate, and one on which we have very little definite information. During the period under review approximately 350 lambs from the same flock, run out without selection from the main body, were sent to winter on lowland farms, having a reputation both for doing stock well and for the subsequent progress of that stock on its return to the hill pastures. In every case these lambs showed a loss in weight, the average for the whole 350 being a loss per lamb of 1.1 lb. So that when the live weight of these

lambs is compared with that of those wintered on the old pasture together with two hours daily on the timothy rows, we find that while the former show an average loss of over one pound, the latter show an increase of half-a-pound per head. As regards condition the timothy wintered sheep were at least the equal of those from the lowlands. It appears, therefore, that there is considerable justification for a continued study of systems aiming at the production of winter keep on similar lines to that described in this article. It is necessary to explore the ways and means of producing winter grass at intermediate elevations (above 800-900 feet), and to study the effect on the lambs while converting such grass, and also their subsequent behaviour when they become mature sheep on the open hill.

Acknowledgements.

We desire to express our thanks to Professor Stapledon, C.B.E., M.A., Director of the Cahn Hill Improvement Scheme, at whose instigation the work was commenced, for his continued helpful interest and criticism. Thanks are also due to Professor Fagan, M.A., for carrying out the chemical analysis.

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THE REDUCTION OF METHYLENE BLUE AT 15.5°C (60°F) AS A TEST OF KEEPING QUALITY OF MILK.

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The technique outlined in the Guide to the Conduct of Clean Milk Competitions[1] involves the examination of milk samples by taste and clot on boiling twice daily. It is very unpleasant to carry out and is dependent to a large extent on the personal

factor. Errors are especially liable to occur when large numbers of samples are examined daily due to the inability of detecting a slight taint after dealing with a badly tainted sample.

Any method which would remove the necessity for tasting and eliminate the personal factor would be welcomed by laboratory workers and would tend to standardise the results of different workers and laboratories. It has already been reported[2] that there is a close relationship between keeping quality as determined by taste and the reduction of methylene blue when both tests are carried out at 15.5°C. Usually the end point of the decolorisation of methylene blue in milk at this temperature is easily determined and should not be dependent on the personal factor.

During 1932-34 a large number of comparisons of the keeping quality test with reduction of methylene blue at 15.5°C were carried out at Aberystwyth and at Harper Adams Agricultural College. The object was to determine the agreement that might be expected between routine determinations of keeping quality and the time taken for reduction of methylene blue when carried out at the same temperature.

Methods.

The samples dealt with can be divided into two Groups. Series I was examined during 1932-3 and Series II during 1933-4. The methods adopted during the two periods differed slightly and are given below.

Series I. (Preliminary).

The keeping quality was calculated as described in the Guide to Clean Milk Competitions, the rather arbitrary method of calculating to within a quarter day being adopted, but for the purposes of this investigation results have been recorded to the nearest half day.

The methylene blue test was carried out on 20 ml. of milk contained in $6 \times \frac{5}{8}''$ test tubes closed with cotton wool plugs. Sufficient methylene blue was added (1 ml. of an aqueous solution made by dissolving one Blauenfeldt and Tvede tablet in 400 ml. of sterile distilled water) to give a concentration of approximately 1 :800,000. The tubes were incubated at 15.5°C and were not shaken at any time during the test. They were examined twice daily at 9 a.m. and 5 p.m., and the time taken from milking to complete reduction of the methylene blue was taken as the measure to be compared with keeping quality determined in the manner described above.

Series II.

The methylene blue test was slightly modified in this series. The test tubes were closed with sterile rubber bungs and were inverted three times subsequent to examination at 9 a.m. and 5 p.m. daily.

The keeping quality was determined on the development of a distinct taint. In cases of doubtful taint this was only sufficient to condemn the sample if followed by a distinct taint at the next test.

The relation between keeping quality and methylene blue reduction time.

The total number of comparisons carried out was 1,962 of which 716 were in Series II.

Series I. (Preliminary).

The results of Series I are given in Table I in the form of a correlation table.

TABLE I.

The relation between Keeping Quality and Methylene Blue Reduction Time. Series I. 1932-33. 1246 Samples.

Keeping Quality (Half Days).	Methylene Blue Reduction Time—Half Days.											Total.
	2	3	4	5	6	7	8	9	10	11	12 *and over.*	
2	9	1										10
3	19	31	6	1	1							58
4	34	56	72	8	6		1					177
5	17	36	98	69	18	1	1					240
6	13	21	74	55	85	16	16	3	2		3	288
7	3	14	36	59	68	50	30	20	6	1	8	295
8			5	14	35	15	31	11	8	3	4	126
9				2	4	8	3	8	4	2	10	41
10				1		2	1	2	2		3	11
Total	95	159	291	209	217	92	83	44	22	6	28	1246

From the data in Table I has been calculated the average keeping quality in half days corresponding with each half day for methylene blue reduction. These results are given in Table II.

From column (3) of Table II it will be observed that at each half day up to the seventh the methylene blue reduction time is less than, while beyond the seventh half day it is greater than, the corresponding average keeping quality. Further, in Table I the range of variation of keeping quality for each half day of methylene blue reduction is considerable, so that although there is some connection between the two measures of keeping quality the relationship is not very close.

TABLE II.

Relation between average keeping quality and methylene blue reduction time. Series I.

Methylene blue reduction time (half days) (1)	*Average keeping quality. (half days)* (2)	*Difference (half days)* (3)	*No. of samples* (4)
2	4.16	—2.16	95
3	4.55	—1.55	159
4	5.26	—1.26	291
5	6.04	—1.04	209
6	6.54	—0.54	217
7	7.21	—0.21	92
8	7.24	+0.76	88
9	7.67	+1.83	44
10	7.91	+2.09	22
11	8.02	+2.98	6
12 & over	8.07	+3.93	28

Series II.

The results from the second series of comparisons are given in Table III in the form of a correlation table. As has been pointed out the methylene blue tubes were stoppered and shaken twice daily so that conditions would approximate more closely to those in the keeping quality bottles. In addition keeping qualities were only determined to the first taint, which would appear theoretically to agree more closely with the reduction of methylene blue.

TABLE III.

Relationship between Keeping Quality and Methylene Blue Reduction Time. Series II. 716 Samples.

KEEPING QUALITY (Half Days).	METHLYENE BLUE REDUCTION TIME—HALF DAYS.									TOTAL.
	2	3	4	5	6	7	8	9	10	
2	12	2								14
3	8	57	4	1						70
4	1	42	72	11	2					128
5		16	45	87	10	4				162
6			21	62	88	6	1			178
7				15	35	72	12	1		135
8						12	13		1	26
9						2		1		3
Total	21	117	142	176	135	96	26	2	1	716

An equation of the second degree was fitted to the data given in Table III to describe the relationship between the keeping quality, y, and the number of half days required for the reduction of methylene blue, x.

The equation obtained was

$$y = 0.13 + 1.296\,x - 0.0466\,x^2$$

The standard error of an estimate of y obtained from this equation is 0.71 half days.

In Table IV the average observed keeping quality for each half day of methylene blue reduction is compared with that calculated from the above equation by substituting the appropriate values for x.

TABLE IV.

Relation between keeping quality and methylene blue reduction time

Methylene Blue reduction time (half days) (a)	*Average keeping quality (half-days).* Observed (b)	Calculated (c)	*Differences.* (a)—(b)	(b)—(c)	*No. of Samples.*
2	2.48	2.54	—0.48	—0.06	21
3	3.62	3.60	—0.62	+0.02	117
4	4.58	4.57	—0.58	+0.01	142
5	5.45	5.45	—0.45	0.00	176
6	6.16	6.23	—0.16	—0.07	135
7	7.02	6.92	—0.02	+0.10	96
8	7.48	7.52	+0.52	—0.04	26
9	8.00	8.02	+1.00	—0.02	2
10	8.00	8.44	+2.00	—0.44	1

Comparison of the above table with Table II shows that the results of the second series exhibit the same features as Series I, *i.e.*, up to seven half-days, the keeping quality is greater than, and from seven half-days upwards is less than the methylene blue reduction time. The range of variation of keeping quality for each half-day of methylene blue reduction time is, however, much narrower than with Series I and there is, therefore, a much closer relationship between the two measures obtained in the second Series.

The estimates of the keeping quality obtained by the use of the equation above show very close agreement with the average observed keeping qualities, but it should be noted that only a small number of samples were examined in which the methylene blue reduction time was greater than seven half-days.

The estimates given under (*c*), Table IV, corresponding with the observed times of methylene blue reduction, would, under conditions similar to those of this investigation, be expected in 95 per cent. of cases to be within 1.4 half-days (twice the standard error) of the keeping quality as measured by the time taken for the development of taint, determined by taste.

Summary and Discussion.

It has been shown that to obtain a close relationship between the reduction of methylene blue at 15.5° C. and keeping quality as determined by taste it is necessary to carry out the test in closed tubes which must be shaken at least twice daily. If this is done the methylene blue reduction time within seven half-days is less and beyond seven half-days greater than the directly observed keeping quality, *i.e.*, the methylene blue test is more sensitive than the direct method. If the reduction of methylene blue is a direct measure of keeping quality this would be expected, as a small change in the redox potential round the reduction point of methylene blue would be more easily determined colorimetrically than by slight changes in taste. It is difficult to account for the contrary results obtained for reduction times in excess of seven half-days. The types of bacteria present undoubtedly have an important bearing on the results. It has been reported that lactic acid producing organisms lower the redox potential very rapidly as compared with other types. It would be expected that lactic acid bacteria would predominate in milks with poor keeping quality, while non-acid producing types might be most numerous in milks with good keeping quality. In this connection it has been noticed that milks containing few organisms, and usually having a keeping quality greater than six half-days, often develop a putrefactive rather than an acid taint. Unfortunately no notes were made of the type of taint which condemned the sample.

The variation from the mean value of keeping quality is wide, but certain errors in the tasting method must be taken into account. There are day to day variations in the sense of taste of the worker carrying out the test, and the influence of tasting a succession of samples is considerable. An error of one, and in certain instances two, half-days can be easily visualised in tests by the ordinary method.

When these considerations are taken into account the agreement between the two methods is remarkably close. Even if the methylene blue test does not give an absolute measure of the keeping quality of milk as determined by taste it gives a comparable, and perhaps more accurate, indication of the true keeping quality. It is much easier and quicker to carry out and should give results which are always comparable between different laboratories and workers.

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[1] Ministry of Agriculture & Fisheries. *Bull.* No. 46 (1932).

[2] Mattick and co-workers. (1933). *J. of Dairy Res.*, 4, 120.

THE INFLUENCE OF MANAGEMENT ON THE CHEMICAL COMPOSITION OF PASTURES IN WINTER.

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A striking feature of the country-side towards the end of 1934 and the beginning of 1935 was the healthy green colour of many of our pastures, especially those that had been closely grazed during the previous autumn and rested in early winter. The appearance of these pastures more closely resembled that of April and May than is generally associated with November to February. Of the fields in the immediate neighbourhood of Aberystwyth, there were few that showed these characteristics more clearly than the rotationally grazed fields of the College Farm, Nantcellan.

The season was in many respects abnormal. The drought that occurred during the growing period of 1934 was followed by rain in November and a fall of rain above the normal in December. The temperature also was far above the average, in fact, ground frost was only registered on some seven occasions up to the end of February. The heavy rainfall following the drought was accompanied by one of the mildest winters experienced for the last fifty or sixty years, and this combination of climatic conditions was no doubt responsible for the forward appearance of the herbage of these pastures.

At the end of February, 1935, samples of the herbage were taken for chemical examination from two of the rotationally grazed plots (Numbers 3 and 4) at the College Farm, Nantcellan. When sampling, the bulk of growth was found on closer examination to be disappointing, and by no means reached the standard its appearance at a distance would lead one to expect. The herbage was mainly composed of the earlier grasses, *e.g.*, meadow foxtail and tall fescue, for at that time the finer grasses had not made any great progress. From an examination of the figures in Table I it will readily be seen that this type of herbage provided a valuable acquisition to the foodstuff and especially at a time when in the general course of events there is scarcity of grass. For at the end of February there is usually very little "keep" on most farms.

The soil of the rotationally grazed fields at Nantcellan is of two types, a sedentary portion formed from Ordovician shales,

lighter in character than the remainder, which is typical boulder-clay. The herbage samples taken from each formation were kept separate, and in Table I those taken from the sedentary portion are marked (*a*), while those from the boulder-clay marked (*b*).

TABLE I.

Showing the composition of the herbage of four samples taken from the rotationally grazed fields at Nantcellan on the 28th February, 1935.

Field number	3(*b*)	3(*b*)	4(*a*)	4(*b*)
Moisture	84.3	83.4	82.6	83.5
	Based on dry matter.			
Ether extract	7.44	6.22	5.90	5.90
Crude protein	28.78	28.70	27.82	28.43
True protein	23.27	21.78	21.07	21.07
Fibre	15.20	16.05	15.70	15.34
Ash	10.51	11.25	10.24	10.25
Soluble carbohydrates	38.07	37.78	40.34	40.08
Silica free ash	7.11	7.21	6.64	6.45
Phosphoric acid (P205)	0.81	0.77	0.77	0.81
Lime (CaO)	0.77	0.78	0.76	0.76

The distinctive character of the dry matter, from a chemical point of view, is its high protein content, and as the date of sampling precludes the possibility of any clover being included in the sample the percentage of protein is still more impressive. We have not in our work of pasture analyses previously met with samples wholly composed of grasses with so high a protein content, in which constituent the dry matter of the samples under consideration compares with that of linseed cake. This is probably explained by the fact that, apart from these rotationally grazed fields being well supplied with all the essential elements of plant food, the growth was that of young grass, which is always richer in protein than more mature grass. Again, as already mentioned, the herbage was mainly composed of meadow foxtail and tall fescue which, in our work with individual grasses, were well above the average in protein content, in fact, meadow foxtail has always been outstanding in this respect (1).

From Table I it is seen that although the herbage samples taken from the sedentary and transported soil types of each field were examined separately, the difference in chemical composition between them is negligible. This is what would be expected, as both portions of each field were manured and managed in the same way.

It is, however, on comparing the chemical composition of this herbage with that taken from fields in the neighbourhood where the same care and attention had not been paid to their grazing and management that the value of this growth becomes most apparent. This is done in Table II, where the average

chemical composition of the four samples taken from the rotationally grazed fields is compared with the average of four samples taken from fields managed and grazed as is customary in the country side.

TABLE II.

	Average from rotationally grazed fields.	*Average from fields as customarily grazed.*
Moisture	83.45	75.60
Based on dry matter.		
Ether extract	6.36	3.54
Crude protein	28.43	14.81
True protein	21.80	12.50
Fibre	15.57	22.62
Ash	10.56	12.54
Soluble carbohydrates	39.08	46.49
Silica free ash	6.93	4.08
Phosphoric acid (P2O5)	0.79	0.68
Lime (CaO)	0.77	1.11

In the above Table, the herbage of the fields which were grazed in the customary manner contained a fair percentage of winter burn which, although not present in excessive amounts, yet had a deteriorating effect upon the nutritive value of the produce as shown by its low protein and high fibre content (2).

The main object of this short note is to draw attention to the benefits that follow, even in winter, a system of pasture management such as that practised in rotationally grazed plots. These benefits are not confined to the chemical composition of the herbage, but they also manifest themselves in the power of recovery such pastures possess, in that they provide valuable winter grazing for the flock which is more or less continuous throughout the winter, and that without any apparent deterioration provided the grazing is followed by short periods of rest.

Again under this system of management, the herbage is kept in that stage of growth where it is possible to take advantage of any favourable climatic conditions prevailing. The greenness of these pastures indicate the high manurial condition of the land as well as the sound root development of individual plants. In fact, their whole appearance is a promise of an early start of growth in the spring. Even when the growth of the herbage is small it acts as a tonic to grazing animals, and provides them with a natural " lick." Live stock grazing under these conditions remain contented for a considerable time each day on the pastures, whereas on benty, starved and badly grazed pastures they congregate near the gates awaiting food to be brought to them.

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PASTURE MANAGEMENT AND ITS EFFECT ON THE SWARD.

Part III.—A POOR *AGROSTIS* PASTURE.

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A series of experiments designed to test the effect of extreme methods of management on widely differing types of pastures were started in 1929. The preliminary reports on three of these pastures have already appeared in Volumes X and XI of this *Journal* (1 and 2). The present paper gives the results of a fourth experiment, laid out on Wood Field slope on the Welsh Plant Breeding Station Farm.

The area under discussion is situated on a steep slope with a north-easterly aspect. The cropping and management of this area previous to 1929 were as follows :—

1914—roots, with farmyard manure and artificials.

1915—barley.

1916 and 1917—hay crops.

1918—barley.

1919—wheat.

1920—oats.

1921—fallow.

1922-1924—pure plots of grasses, no grazing was allowed on these plots, the herbage being removed as hay or pasture cuts.

1925-26—same plots, grazed with sheep and horses and ploughed November, 1926.

1927—sown with Italian rye-grass in early spring. During the following autumn and winter it received eight applications of nitrogenous manure, 2½ cwt. as sulphate of ammonia and 3 cwt. of nitrate of soda.

1928 and 1929—grazed by sheep and horses until August, 1929, when the present experiment was started.

From the above notes it is seen that :—

(1) between 1915 and 1924

(*a*) no manures were applied.

(*b*) all crops were removed.

(*c*) there was practically no grazing and thus only a small amount of animal droppings.

(2) The grass seeds sown in 1927

(*a*) consisted entirely of Italian rye-grass.

(*b*) were heavily manured during the first twelve months with nitrate of soda and sulphate of ammonia.

As a result of this management the area was very low in fertility and had a poor type of herbage, consisting almost wholly of self-volunteering grasses. This is shown in the following statement, which gives the percentage composition of the sward in August, 1929 :—

	Per cent.
Bent	78.0
Yorkshire fog	4.8
Fine-leaved fescue	5.0
White clover	1.7
Italian rye-grass	.9
Perennial rye-grass	1.3
Rough-stalked meadow grass	1.1
Sweet vernal	1.0
Cocksfoot	.2
Crested dogstail	.7
Miscellaneous weeds	5.3

Conduct of Experiment.

The method of conducting the experiment, together with the intensities of grazing and the manner of collecting the data have been described in the previous reports. It is therefore sufficient to give only a short description of the experiments in this paper. The following gives the list of treatments to which the pasture was subjected :—

(1) Hard grazing[1]—throughout the season[2].

(2) Hard grazing in spring
(3) Hard grazing in summer
(4) Hard grazing in autumn
} and moderate grazing during rest of grazing season.

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[1] Hard grazing corresponds to eighteen sheep per acre and grazed every week.
Moderate grazing corresponds to seven sheep per acre and grazed every month.
Light or undergrazing corresponds to five sheep per acre and grazed every two months.

[2] The grazing season usually extended from mid-April to mid-October.
Spring extended from mid-April to mid-June.
Summer extended from mid-June to mid-August.
Autumn extended from mid-August to mid-October.

(5) Normal or moderate grazing.
(6) Light or under-grazing.
(7) Mown every two months.
  (*a*) mown herbage removed.
  (*b*) mown herbage allowed to rot on plot.
(8) Ungrazed-unmown.
(9) Mown for hay and aftermath—all herbage being removed.

The pasture was subjected to these treatments from August, 1929, to October, 1933, inclusive. No manures were applied apart from the sheep droppings on the plots when they were grazed.

Botanical Composition of the Sward.

The effect of the different types of management on the botanical composition of the sward is shown in Tables I and II and Fig. 1. These give a summary of the data collected from five plots. The data collected on the plots grazed hard at different seasons of the year, and also those relating to the different systems of mowing will be discussed later. In the present section only the data from the plots grazed hard throughout the grazing season and from those mown every two months and the mown herbage removed will be discussed, together with the moderately-grazed plots, the under-grazed plots and the ungrazed-unmown plots.

Table I and Fig. 1 show the percentage botanical composition of the plots in 1934; this is based on tiller counts. From these it is seen that :—

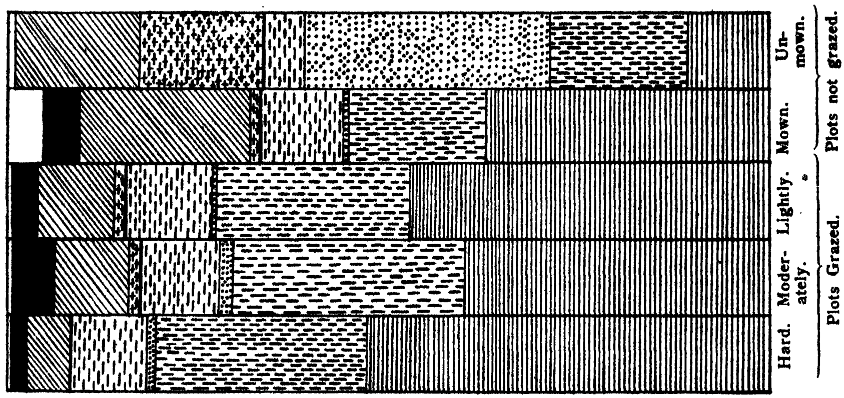
(*a*) The sward on the plots is composed mainly of bent, except on the ungrazed-unmown plots on which Yorkshire fog is the main species.

(*b*) The percentage tiller contribution of each species varies from plot to plot. Bent forms about 66 per cent. of the sward on the hard grazed and moderately grazed plots, 58 per cent. on the lightly grazed plots, 50 per cent. on the mown areas and only 36 per cent. on the ungrazed-unmown plots. Yorkshire fog forms between 12 and 14 per cent. on the grazed plots, 26 per cent. on the mown plots and nearly 42 per cent. of the tillers on the ungrazed-unmown plots. Sweet vernal forms only 0.2 per cent. of the tillers on the hard grazed plots, whereas it contributes between 3 and 6 per cent. on all other plots. White clover forms 5.8 per cent. of the tillers on the moderately grazed plots, 4.8 per cent. on the undergrazed plots, 3.3 per cent. on the mown

plots, 2.8 per cent. on the hard grazed plots, and only 0.8 per cent. on the ungrazed-unmown plots. Weeds form between 9 and 12 per cent. of the tillers on the hard grazed plots, the mown

FIG. 2.

Showing the effect of the different types of management (1929-33) on the percentage botanical composition (by weight) of the herbage cut from the plots during 1934.



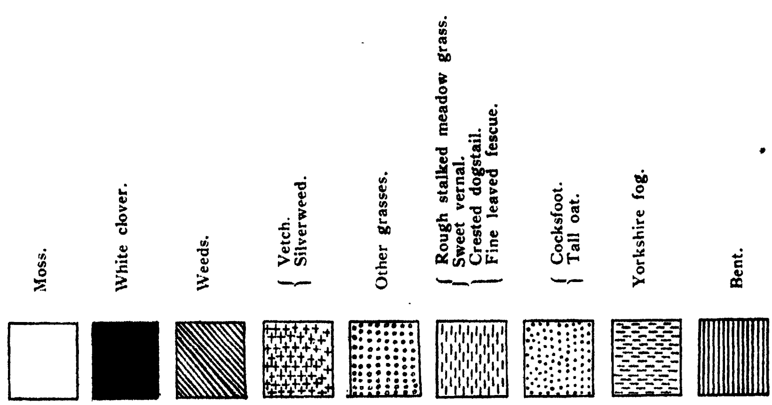
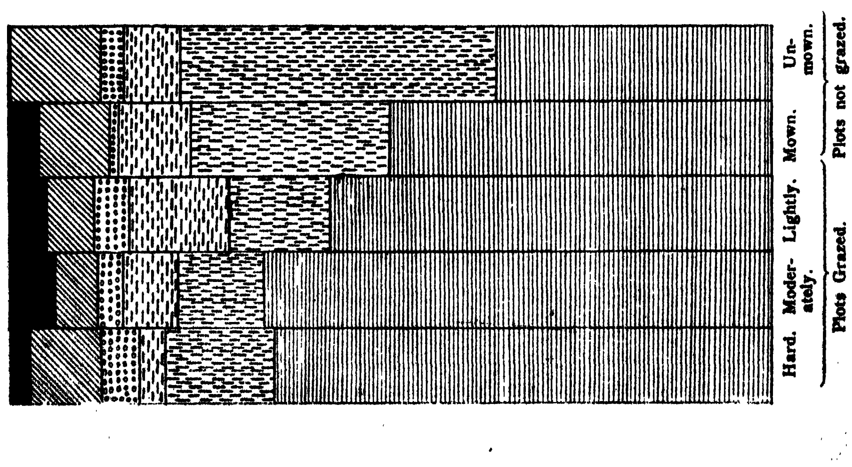


FIG. 1.

Showing the effect of the different types of management (1929-1933) on the percentage botanical composition (tiller counts) of the sward in 1934.



plots and the ungrazed-unmown plots, whereas on the lighter grazed areas they only contribute about 6 per cent. of the tillers.

TABLE I.

The percentage botanical composition of the sward on the different plots (based on tiller counts November, 1934).

Species.	*Plots grazed.*			*Plots not grazed.*	
	*Hard.**	*Moderately*	*Lightly.*	*Mown*†	*Unmown*
Bent	65.1	66.4	57.7	50.4	36.3
Yorkshire fog	14.6	11.6	13.6	25.9	41.5
Sweet vernal	.2	4.0	5.6	3.6	3.0
Crested dogstail	1.4	1.6	4.1	2.4	2.6
Fine-leaved fescue	1.6	1.5	3.2	.3.6	1.6
White clover	2.8	5.8	4.8	3.3	.3
Weeds	9.3	5.6	6.2	9.7	11.6
Other grasses	5.0	3.5	4.8	1.1	3.1

* Includes only plot grazed hard throughout season.
† Includes only plot mown and herbage removed.

Table II shows the relative number of tillers of certain species on the different plots in November, 1934. Unlike Table I, where the pasture is taken as the unit and where all values are expressed as percentages of this unit, in Table II the species is taken as the unit, and the figures represent a comparison of the number of tillers of each species present in the herbage under the different methods of management. For each species the highest number of tillers per unit of area is placed at 100, and the value for other plots are calculated relative to this.

On referring to Table II it is seen that

(*a*) The total number of tillers per unit of area was higher on the grazed than on the ungrazed plots. The highest number was obtained on the plots grazed moderately, the other grazed plots having about 15 per cent. fewer tillers compared with the number of tillers on the moderately grazed plot, the mown plots had just over half that number, whereas the number on the ungrazed-unmown plot was less than half. In previous experiments it was found that the densest pasture was obtained on the hardest grazed plots (2), yet in this experiment it was found on the moderately grazed plots.

(*b*) The results for bent were similar to those obtained for "total tillers," but more pronounced. One would expect this agreement on account of the high percentage of bent in the sward. The highest number of bent tillers per unit of area was found on the moderately grazed plot, the number on the hard grazed plots being about 15 per cent. less and that on the undergrazed

plots about 28 per cent. less. The number of bent tillers on the mown plots was only 48 per cent., and that on the ungrazed-unmown plots only 24 per cent. of the number on the moderately grazed plots. In the previously reported experiments (1 and 2),

TABLE II.

The relative number of tillers of certain species on the plots in December, 1934. (The highest number for each species is placed at 100).

	Plots grazed.			*Plots not grazed.*	
	Hard.	*Moderately*	*Lightly.*	*Mown*	*Unmown*
Total tillers	86	100	84	56	44
Bent	85	100	72	48	24
White clover	43	100	69	33	8
Weeds	100	69	65	68	60
Sweet vernal	4	84	100	42	28
Crested dogstail	85	47	100	39	38
Fine-leaved fescue	58	57	100	76	27
Yorkshire fog	70	65	68	84	100

the highest number of bent tillers was obtained on the hard grazed plots; apart from this the figures agree.

(*c*) White clover also gave results similar to those for "total tillers," but the variation from plot to plot was still more pronounced even than for bent. The highest number of tillers per unit of area of white clover was found on the moderately grazed plots. The undergrazed plots had 31 per cent. fewer tillers and the hard grazed plots 57 per cent. fewer tillers than the moderately grazed plots. The number of tillers of white clover had been reduced to 33 per cent., or one-third, on the mown plots, and to about 4 per cent. on the ungrazed-unmown plots as compared to the moderately grazed plots.

(*d*) Weeds were more plentiful in numbers on the hard grazed plots. The variation in the number of weeds on the other four plots was small, the moderately grazed plots and mown plots having the highest and the ungrazed-unmown plots the lowest number of weeds.

(*e*) Sweet vernal, crested dogstail and fine-leaved fescue were similar in that they were all more plentiful on the grazed areas, especially the lightly grazed areas. Hard grazing, however, decreased the numbers of each species; this being most noticeable in the case of sweet vernal which was almost absent on the hard grazed plots. In addition all three species were

fewer in number on the ungrazed-unmown plots than on the mown plots.

(*f*) Yorkshire fog differed from the previous species in that it was more plentiful on the ungrazed plots. It gave its highest number of tillers per unit of area on the ungrazed-unmown plot, the mown plots having about 16 per cent. fewer and the grazed plots between 30 and 37 per cent. fewer tillers. As in a previous experiment (2) it is possible that the high figure for Yorkshire fog on the ungrazed-unmown plots was partly due to colonisation during 1934 when the data were collected, though in this case if colonisation by fog did occur during that year it was not nearly so marked as in the previous experiment.

Yield of herbage and the variation in its botanical composition.

During 1934 small areas from each plot were protected against grazing. The herbage on parts of these areas was cut three times, *viz.*, June 20th, August 22nd and November 9th; on other parts it was cut for hay only on July 23rd. The data from these two systems of cutting were similar. On this account they have been combined and all figures relative to yield are the average of the hay and pasture cuts.

TABLE III.

Showing the percentage botanical composition (by weight) of the herbage (average of hay and pasture cuts).

	Plots grazed.			*Plots not grazed.*	
	Hard.	*Moderately*	*Lightly.*	*Mown*	*Unmown*
Grasses	91.7	82.6	84.5	66.7	66.5
Weeds	5.7	11.4	11.6	23.8	32.5
Clover*	2.0	5.2	3.1	4.7	—
Moss	.6	.8	.8	4.8	1.0
Bent	52.8	40.0	47.2	37.1	10.7
Yorkshire fog	27.7	30.3	25.1	18.0	18.2
Cocksfoot	.9	1.1	.3	.5	18.9
Tall oat	.2	.5	.1	.2	13.2
Silver weed	T	.7	.9	.2	10.6
Vetch†	—	.9	.9	1.1	5.6
Rough-stalked meadow grass	2.2	.6	1.8	1.1	.1
Sweet vernal	.5	3.1	1.0	2.8	1.7
Crested dogstail	1.1	3.4	1.6	1.3	.4
Fine-leaved fescue	2.0	1.3	5.3	6.2	2.6

* All white clover except 0.5 on the moderately and 0.2 on the lightly grazed plots.

† Including *Vicia* species and *Lathyrus pratensis*.

Table III and Fig. 2 show the percentage botanical composition, by weight, of the herbage cut during 1934. These show that the percentage contribution of grasses as a group was highest on the hard grazed plots, where they formed about 92 per cent. of the herbage, and lowest on the ungrazed plots, where they only contributed about 67 per cent. of the total herbage. The percentage contribution of the various weeds, however, increased as the intensity of the grazing decreased from about 6 per cent. on the hard grazed plot to about 11 and 12 per cent. on the lighter grazed areas, to nearly 24 per cent. on the mown areas, and finally to nearly 33 per cent. or one-third of the total herbage on the ungrazed-unmown plot. Clover gave its highest percentage contribution on the moderately grazed plots, the hard grazed plots giving a much lower contribution, whereas at the other extreme the ungrazed-unmown plots gave no clover in the cut herbage. The only other group of species contributing to the herbage were the mosses; their contribution was almost negligible except on the mown area, where it was nearly 5 per cent.

Of the individual species Table III shows that bent gave the highest contribution on all plots except on the ungrazed-unmown plots. Its percentage contribution varied from about 53 per cent. of the herbage on the hard grazed plots to about 10 per cent. on the ungrazed-unmown plots; on the other plots its percentage contribution lay between these extremes. Yorkshire fog gave a similar percentage for all grazed plots, but a much lower percentage contribution on the ungrazed plots. The contribution of cocksfoot, tall oat, silver weed and vetch[3] was almost negligible, 1 per cent. or less, on all plots except the ungrazed-unmown plots where they contributed 18.9, 18.2, 10.6 and 5.6 per cent., respectively, of the total herbage. Other species such as rough-stalked meadow grass, sweet vernal, crested dogstail, and fine-leaved fescue were rarely present in quantities larger than about 8 per cent., and thus, although their percentage contribution varied considerably from plot to plot, these variations affected the pasture only to a slight degree.

Table IV and Fig. 3 show the relative yield of herbage both as regards individual species and groups of species. From this Table it is seen that:

(a) The total yield of herbage was higher on the grazed than on the ungrazed plots, and further, on the grazed plots the harder the grazing, the higher the total yield. The total yield of herbage on the moderately grazed plots was only 88 per cent. and on the

[3] Including *Vicia* species and *Lathyrus pratensis*.

undergrazed plots only 81 per cent. of the yield on the hard grazed plots. On the ungrazed plots the unmown plots gave 67 per cent. and the mown plots only 44 per cent. of the total yield obtained on the hard grazed plots. This shows that the low

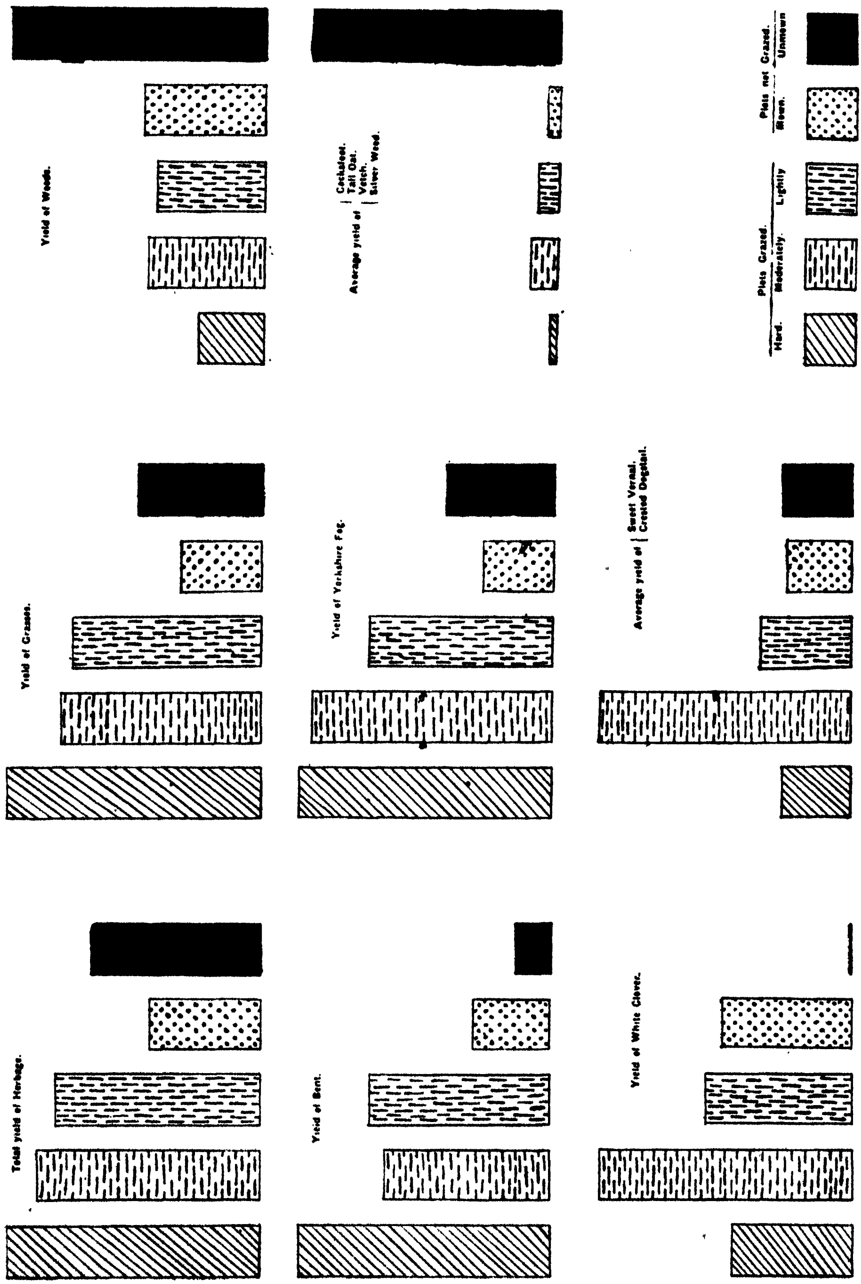


Fig. 3.—Showing the effect of the different types of management (1929-1933) on the yield of herbage, both as regards individual species and groups of species. For each species or group of species the highest yield is placed at 100, and their yields on the other plots are calculated accordingly.

fertility of the area was lowered still further by continuously cutting and removing the cut herbage, whereas grazing improved the fertility.

TABLE IV.

The relative yield of herbage (a) Total yield and yield of groups of species; (b) Individual yield of species.

	Plots grazed.			*Plots not grazed.*	
	*Hard**	*Moderately*	*Lightly.*	*Mown*	*Unmown*
(a)					
Total yield	100	88	81	44	67
Yield of grasses	100	79	75	32	49
Yield of weeds	26	46	43	48	100
(b)					
Bent	*100*	66	72	31	14
Yorkshire fog	*100*	95	73	28	44
White clover	48	*100*	58	51	0
Sweet vernal	19	*100*	32	33	48
Crested dogstail	36	*100*	41	19	9
Fine-leaved fescue	48	27	100	64	41
Cocksfoot	7	8	2	2	100
Tall oat	2	5	1	1	100
Vetch	—	21	19	13	100
Silver weed	1	8	10	2	100

(*b*) In regard to the grasses as a whole the decrease in yield on the lighter grazed and ungrazed plots was more pronounced than the decrease in yield of total herbage. When compared with the hard grazed plots where the grasses gave the highest yield, their yield on

(i) the moderately grazed plots was 79 per cent.
(ii) the lightly grazed plots 75 per cent.
(iii) the ungrazed-unmown plots 49 per cent.
(iv) the ungrazed-mown plots only 32 per cent.

(*c*) Weeds gave their highest yield on the ungrazed-unmown plots, their yields on the other plots being less than half. Compared with the yield of weeds on the ungrazed-unmown plots, their yield

(i) on the mown plots was 48 per cent.
(ii) on the moderately and lightly grazed plots 48-46 per cent.
(iii) on the hard grazed plots only 26 per cent.

Taking the species singly it is seen that only two grasses, namely, bent and Yorkshire fog, have given their highest yields

on the hard grazed plots. On the lightly grazed plots the yield of these two grasses was only 72-78 per cent. of their yield on the hard grazed plots, and on the mown plots it was reduced to about 30 per cent. On the ungrazed-unmown plots the yield of bent was only 14 per cent. whereas the yield of Yorkshire fog was 44 per cent. of their respective yields on the hard grazed plots.

White clover, sweet vernal and crested dogstail gave their highest yield on the moderately grazed plots, and their yield on all other plots was much less. The yield of white clover on the lightly grazed plot was only 58 per cent. and on the hard grazed plots and the mown plots it was only about 50 per cent. of its yield on the moderately grazed plot. On the ungrazed-unmown plots no white clover was found in the cut herbage. The yield of sweet vernal was reduced to 19 and 32 per cent. on the hard and lightly grazed plots, and to 33 and 48 per cent. on the mown and the ungrazed-unmown plots, respectively. Crested dogstail on the other hand gave 36 and 41 per cent. of its highest yield on the hard and the lightly-grazed plots and only 19 and 9 per cent. on the mown and the ungrazed-unmown plots. These figures suggest that crested dogstail thrives better than sweet vernal under grazing, especially hard grazing, whereas sweet vernal thrives better than crested dogstail in the absence of the grazing animal.

Fine-leaved fescue gave its highest yield on the lightly grazed plots, and compared with this its yield

(i) on the mown plots was 64 per cent.

(ii) on the ungrazed-unmown plot 41 per cent.

(iii) on the harder grazed areas between 27 and 48 per cent.

Unlike all other species mentioned in this paper, cocksfoot, tall oat, vetch and silver weed gave their highest yields on the ungrazed-unmown plots. In the case of the two grasses their yield on any of the other plots was almost negligible, being rarely 5 per cent. of their yield on the ungrazed-unmown plot. Compared with its yield on the ungrazed-unmown plot, silver weed gave only 8 per cent. of that yield on the moderately grazed plot and 10 per cent. on the lightly grazed plots. Apart from the hard grazed plot where no vetch was found, its yield on the lighter grazed areas and on the mown areas compared more favourably with its yield on the ungrazed-unmown plots—being 20 per cent. and 13 per cent., respectively.

Comparison of the Hard Grazed plots.

In the present experiment four types of hard grazing were tested, *viz.* :—

Plot 1—grazed hard through the whole grazing season.

Plot 2—grazed hard in spring and moderately in summer and autumn.

Plot 3—grazed hard in summer and moderately in spring and autumn.

Plot 4—grazed hard in autumn and moderately in spring and summer.

In the foregoing Tables and discussions, only data from Plot 1 have been used. It is now intended to compare the results obtained under these four systems of hard grazing with one another. Table V shows the relative number of tillers on these plots. From these it is seen that:

(*a*) The variation in the total number of tillers is not so pronounced as the variation of the individual species on the different plots. The highest number of tillers was found on the plots grazed hard through the season (Plot 1) whereas Plot 2 and Plot 4 had 87 and 89 per cent., respectively, while Plot 3 had 93 per cent. of the number in Plot 1.

TABLE V.

The relative number of tillers per unit of area on the four systems of hard grazing.

Species.	*Plots grazed hard during*			
	(*1*) *Grazing season.*	(*2*) *Spring.*	(*3*) *Summer.*	(*4*) *Autumn.*
Total number of tillers	100	87	93	89
Bent	100	92	92	63
Weeds	100	46	39	24
White clover ...	42	41	19	100
Crested dogstail ...	79	95	89	100
Yorkshire fog	58	42	68	100
Sweet vernal ...	6	46	69	100

(*b*) Bent and weeds were more numerous on Plot 1. Bent had 8 per cent. fewer tillers on Plots 2 and 3, and 37 per cent. fewer on Plot 4 as compared to Plot 1. The number of weeds, however, showed a distinct decrease on Plots 2, 3 and 4, being only 46 per cent., 39 per cent., and 24 per cent., respectively, of the numbers found on Plot 1.

(*c*) White clover, crested dogstail and Yorkshire fog and sweet vernal had their highest number of tillers on the plots grazed hard in the autumn—Plot 4. They differ, however, in that white clover had its lowest number of tillers on the plots grazed hard in the summer—Plot 3; Yorkshire fog had its lowest number on the plots grazed hard in the spring—Plot 2, whereas

crested dogstail and sweet vernal had their lowest number of tillers on the plots grazed hard through the grazing season—Plot 1; in fact sweet vernal was practically absent on these latter plots.

Turning to Table VI, which gives the relative yield of herbage on the hard grazed plots, it is seen that

(*a*) The total yield and the yield of grasses were highest on the plots grazed hard in spring, the other plots being from 6 to 10 per cent lower.

(*b*) The yield of weeds was highest on the plots grazed hard in the summer—Plot 3, those grazed hard in the spring being about 5 per cent. lower, whereas the yield on the other two plots —Plots 1 and 4, was about 50 per cent. lower.

TABLE VI.

The relative yield of herbage and individual species obtained from the hard grazed plots.

	Plots grazed hard during			
	(1) Grazing season.	*(2) Spring.*	*(3) Summer.*	*(4) Autumn.*
Total yield	91	*100*	91	90
Yield of grass	96	*100*	89.5	90
Yield of weeds	52	95	100	51
White clover	35	51	34	*100*
Bent	86	*100*	73	52
Crested dogstail	37	67	100	70
Yorkshire fog	65	51	70	*100*
Sweet vernal	29	40	88	100

(*c*) White clover gave its highest yield on the plots grazed hard in autumn; its yield on the plot grazed hard in spring was about 50 per cent. lower, and its yield on the other two plots was about 65 per cent. lower.

(*d*) Bent gave its highest yield on the plots grazed hard in the spring, its yield on Plot 1 being 14 per cent. lower, whereas on Plots 3 and 4 its yield was 27. and 48 per cent. lower, respectively.

(*e*) Crested dogstail gave its highest yield on the plots grazed hard in summer, its yield on Plots 2 and 4 being about 30 per cent. lower, and its yield on Plot 1 about 60 per cent. lower.

(*f*) Yorkshire fog and sweet vernal gave their highest yield on the plots grazed hard in the autumn. They were both reduced by grazing hard in the summer and still further reduced on the plots grazed hard in spring. Sweet vernal, however,

gave its lowest yield on the plots grazed hard throughout the season, whereas Yorkshire fog gave a higher yield on that than on the plot subjected to hard grazing in the spring only.

The effect of exceptionally hard grazing and the absence of the sheep droppings.

Tethered sheep always have a marked tendency to graze harder at the end of the chain than around the peg. As a result the edge of every plot is grazed much harder than the centre. Their manure on the other hand is seldom dropped at the far end of the chain. Thus there is a narrow strip along the side of each plot grazed by tethered sheep which is grazed very hard at each grazing but seldom receives any of the sheep droppings. In collecting data from plots grazed by tethered sheep, all samples are taken from the centre of the plot and none are taken within about four feet of its edge.

When the first pasture samples were taken from this experiment (June 20th, 1934), a few extra samples were taken from the edge of the hard grazed plots. The relative yield of herbage obtained from

(*a*) the edge,

(*b*) the centre of the plots grazed hard through the grazing season is shown by the following figures :—

Yield of plots grazed hard through the grazing season.

	(*a*) *Edge of plot.*	(*b*) *Centre of plot.*
Total yield	35	100
Yield of Bent	27	100
,, ,, Yorkshire fog	41	100
,, ,, White clover	69	100
,, ,, Weeds	52	100

These figures show that very hard grazing in the absence of animal manure reduces the yield of all plants. This is partly due to the sheep pulling up plants or parts of plants when grazing. On a number of occasions when grazing was in progress, the dried base of a number of these grasses was found lying loose on the hard grazed plots, especially along its edges. Although no stolons of white clover were found on the pasture, it was probable that the sheep had pulled up and eaten a number of them—the evidence being that a number of the white clover stolons were without their growing tip, and this suggested that the younger portion of the stolon had been uprooted and eaten.

It seems probable that the continuous " very " hard grazing weakens the root systems to such an extent that the plants are easily uprooted—this condition must also be aggravated by the absence of animal droppings.

Comparison of the mown plots.

Table VII shows the relative number of tillers of certain species on the mown plots. It is seen that the total number of tillers and the number of bent tillers vary only a little on these plots. Yorkshire fog had fewer tillers on the plots where the herbage was allowed to rot than on the other two plots. Sweet vernal was twice as numerous on the hay plots as on the other plots. White clover had its highest number of tillers on the plot where the herbage was allowed to rot and the smallest number on the hay plots. Fine-leaved fescue and weeds were more numerous on the plot mown every two months and the herbage removed; this was more pronounced in the case of the fescue.

TABLE VII.

The relative number of tillers of certain species on the " mown " plots.

	Herbage cut for hay and aftermath.	*Herbage cut every two months.*	
		Removed from plots.	*Allowed to rot on the plots.*
Total number of tillers	100	99	94
Yorkshire fog	100	98	74
Sweet vernal	100	46	51
Bent	99	95	100
White clover	57	64	100
Fine-leaved fescue	16	100	36
Weeds	70	100	70

TABLE VIII.

The relative yield of herbage on the " mown " plots.

	Herbage cut for hay and aftermath.	*Herbage cut every two months.*	
		Removed from plots.	*Allowed to rot on the plots.*
Total yield	90	76	100
Yorkshire fog	88	48	100
Sweet vernal	60	55	100
Bent	82	85	100
White clover	60	76	100
Fine-leaved fescue	40	100	36
Weeds	92	100	88

Table VIII shows the relative yield of herbage cut from the "mown" plots. This Table shows that the total yield of herbage, and also the individual yield of Yorkshire fog, sweet vernal, bent and white clover were highest on the plots mown every two months and herbage allowed to rot, whereas in most of them the lowest yield was obtained on the plots cut every two months and removed. Fine-leaved fescue and weeds, on the other hand, gave the highest yield on the plots cut every two months and herbage removed, and the lowest yield on the plots where the cut herbage was allowed to rot. In this experiment it seems that the fertility of the area was so low that all species, apart from weeds and fine-leaved fescue, benefited by the return of the mown herbage to rot on the plot. In previous experiments Yorkshire fog was the only one of these particular species found to benefit from such a treatment. In the earlier experiments, however, the fertility was higher than in the present one, and thus only species which made heavy demands on fertility benefited by the return of the cut herbage. Bent there stood in the same relation to the higher fertility demanders as the fine-leaved fescue here stands to the fog and the bent.

From the present results it would appear that in demands on fertility, Yorkshire fog stands higher than bent, and bent higher than the fine-leaved fescue, and this is in keeping with general experience.

General Discussion.

An account of the effect of different types of management on a sward of low fertility has been given. As in previous reports (1 and 2) it has been shown that the botanical composition of a pasture depends largely on its management, some species being favoured by grazing, whereas others thrive best in the absence of the grazing animal. The species have thus been grouped as follows :—

Group 1.—Species which thrive best in the absence of the grazing animal.

To this group belong cocksfoot, tall oat and the miscellaneous plants or weeds.

Cocksfoot and tall oat have given almost identical results. They were both so sparse in number on the pasture that their percentage tiller contribution was negligible on all plots. Similarly their contribution to the yield of herbage in 1934 was also negligible, except on the ungrazed-unmown plots. On these latter plots they were amongst the chief contributing species.

Thus any interference in the form of either grazing or mowing depressed the yield of these two grasses.

Miscellaneous weeds or plants that are neither grasses nor clovers were present in larger numbers on the grazed plots, especially the hard-grazed plots, than on the ungrazed plots. On the other hand, their yield was higher on the ungrazed plots, especially the ungrazed-unmown plots, than on any of the other plots—the lowest yield being obtained on the hard grazed plots. This latter fact was mainly due to the presence of the small tillered pearlwort (*Sagina procumbens*), which was present in large numbers on the hard grazed plots, but contributed nothing to yield of herbage. Two of the weeds—vetch and silver weed—thrived decidedly better in the absence of interference by man and his animals. Thus within " weeds " as a group of species one finds that the reaction to management differs for the different species, but in general it may be stated that the small, low creeping and rosette weeds thrive best under grazing conditions, whereas the bigger types of weeds thrive best when least interfered with. The former can be present in large numbers in the pasture and yet contribute but little to the yield of herbage, whereas the latter may only be present in small numbers, but each tiller gives an appreciable yield of herbage. This explains why the hard grazed plots had the highest number of tillers and the lowest yield of weeds, whereas the ungrazed-unmown plots had the lowest number of weed tillers and yet the highest yield of weeds. On the mown areas weeds gave a better yield on plots cut every two months and herbage removed, whereas all other species, apart from fine-leaved fescue, did better on the areas where the herbage was allowed to rot. It is probable that weeds are better able to compete against grasses under low fertility than under higher fertility conditions.

Group 2.—Species which thrive best under the influence of the grazing animal.

Bent, Yorkshire fog, white clover, sweet vernal, crested dogstail and fine-leaved fescue thrived better under grazing than in the complete absence of the grazing animal.

Bent throve better on the hard grazed areas than on the lightly grazed areas. Furthermore hard grazing in spring encouraged bent more than hard grazing in autumn. In the absence of the grazing animal the number of tillers and the yield of grass show a decrease, this being far more pronounced on the ungrazed-unmown plots than on the ungrazed-mown plots.

The number of tillers of Yorkshire fog was higher on the ungrazed areas than the grazed areas. It has, however, been suggested that the high figure for Yorkshire fog on the ungrazed-unmown plot (Table II) may be due to colonisation by that grass during the year in which the data were collected. The yield of Yorkshire fog as shown in Table IV gives a better indication of its reaction to the types of management. This showed that it throve best on the harder grazed areas and worst on the ungrazed plots, especially the mown plot from which the herbage was removed. Unlike bent, hard grazing in the autumn encouraged Yorkshire fog, whereas hard grazing in spring reduced its numbers to about half. This agrees with what happens in everyday agriculture, *viz.*, a field which is always put up for hay and grazing of aftermath in autumn has a high percentage of Yorkshire fog, whereas neighbouring fields which are not put up for hay are usually grazed hard in the spring and have a high percentage of bent.

Unlike the previous experiments, white clover throve much better on the moderately grazed plots than on the hard grazed plots. It seems probable that on account of the particularly low fertility of this area, the intensity of grazing in relation to herbage offering was greater than in the other experiments, and in fact it was too hard for white clover. It has been noticed that when a pasture is grazed very bare sheep will sometimes " run " the stolons of white clover, *i.e.*, get hold of one end and pull up a length of stolon. Evidence of this was seen more than once on this experiment—the broken parts of the stolon protruding from the ground. Apart from the above, the evidence for white clover on the present experiment agreed with previous experiments in that :—

(*a*) It was far more plentiful on the grazed than the ungrazed plots.

(*b*) It was almost absent on the ungrazed-unmown plots.

(*c*) Hard grazing in summer reduced its numbers markedly, whereas hard grazing in spring and autumn are more favourable to its development.

Sweet vernal and crested dogstail throve best on the moderately grazed plots and the lightly grazed plots. Although in the previous experiments these two grasses throve better on the mown areas, yet it is probable that in the present experiment they derived much benefit from the sheep droppings on the moderately grazed plots, and this was all-important on an area of such low fertility. Although the data for these two grasses are

similar, yet there are suggestions that crested dogstail thrives better than sweet vernal under grazing, especially hard grazing, whereas sweet vernal thrives better than crested dogstail in the absence of the grazing animal.

In general it may be stated that :

Overstocking—by close feeding animals such as sheep—prevents the development of new upright shoots such as are found in cocksfoot and tall oat, with the result that large numbers of these plants fail to survive continuous defoliation. Creeping plants such as bent on the other hand send out numerous side shoots which are not so accessible to the animal, and even in patches where the plants have been almost pulled out following on continuous defoliation and drought, such plants as have any life in them are able to spread and recolonise these areas immediately favourable conditions occur, whereas cocksfoot and tall oat are practically spot bound and cannot recolonise areas where they have been reduced to almost nothing. In addition the bare areas are liable to be colonised by annual weeds, *e.g.*, pearlwort.

Understocking, on the other hand, especially if carried to the point of little or no grazing, is likely to favour the stronger types which, in turn, will be able to smother the finer types of herbage. This has been shown in the present series of experiments, where the absence of the grazing animals favours the growth of cocksfoot, tall oat, tall fescue, and *Molinia* amongst the grasses and rushes, willow herb, sneezewort, hogweed, black knapweed, bramble, etc., amongst other species, to the exclusion of bent, rye-grass, white clover, and other more essentially pasture plants.

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THE EFFECT OF SHOOT CUTTING ON THE GROWTH OF ROOT AND SHOOT OF PERENNIAL RYE-GRASS (*LOLIUM PERENNE L.*) AND OF TIMOTHY (*PHLEUM PRATENSE L.*)

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Introduction.

Much work has been done in recent years on the effects of cutting at various stages of growth upon pasture plants. The nutritive aspect has been worked out by Woodman, Blunt and Stewart (7), and by Woodman, Norman and Bell (8), whilst recent work by Martin G. Jones (2) and (3) and his fellow workers deals with influence of management, especially varying the periods of rest, upon the sward. Little has been done to ascertain the effect of cutting or grazing on individual grasses, especially on the root system. The present investigation is an attempt in this direction, working with two contrasting species of grasses, perennial rye-grass as a pasture type, and Timothy as a hay type.

Data was obtained regarding the effects of intensity and frequency of cutting over one year of growth. Between January 29th, 1934, and February 2nd, 1935, the two species were subjected to cuttings at intervals of ten and of thirty days at intensities of one inch, of half-inch above ground level, and also at ground level.

Data for root growth were also obtained at intervals of ten and of thirty days for the same period. For this purpose the whole experiment had to be replicated so that at intervals a complete set of plants could be withdrawn for root examination. To facilitate this the work had to be conducted on plants grown in boxes. The boxes were housed in a greenhouse in which they were protected from the scouring effects of heavy rain and other climatic disturbances.

Method.

Boxes, one foot square in area, were constructed to contain a cubic foot of good garden soil each. Each box contained a complete set of plants uniformly spaced out to provide for the

various types of cutting, together with controls. One side of each box was screwed on and hinged at the base. One box in a series of eleven was opened for root examination with each interval of thirty days, and one of another series of thirty-one with each interval of ten days throughout the investigation.

When drainage was free within the soil, seeds were sown on January 29th, 1934, and the plants were allowed to establish themselves undisturbed for a period of seventy days. Shoot cutting commenced according to schedule on April 9th, 1934. Both fresh and dry weights of shoots were recorded from each cutting, and by withdrawing at the time of each cutting a box from each series, we obtained records of length of root system, fresh and dry weights of the roots, and the number of tillers per plant at that stage. The data at the time of the first cutting recorded the progress of the plants over the seventy day establishment period. At subsequent cutting days a box was withdrawn from each series (lettered and numbered), and similar data, in progression, was obtained.

Results and Interpretation of Results.

GROWTH DURING ESTABLISHMENT PERIOD.

Perennial rye-grass. Germination was rapid and complete by the fifteenth day. As the plants tillered they became more prostrate. By the end of the establishment period there were from ten to fourteen tillers to each plant. The plants developed three distinct types of roots; young short roots, thick and succulent, more mature roots which were thin and very much branched, and long unbranched thick succulent roots.

Timothy. Germination in timothy was much slower, and the growth rate was generally lower than in rye-grass. The seedlings maintained the erect habit, and at the time of the first cutting the shoot generally consisted of two or three tillers; a number of plants had produced no tillers, while some vigorous plants had as many as five tillers.

GROWTH AFTER COMMENCEMENT OF CUTTING OF THE UNCUT CONTROLS.

Root growth—perennial rye-grass. The root weight rises rapidly to a maximum on June 28th. Subsequently it falls equally rapidly. During this same period the length of the root system as represented by the length of longest root, reaches its maximum earlier than the maximum for root weight. It maintains its length until near the end of the experiment, fluctuating between sixty and seventy centimetres. Fluctuations are found

in all figures, due to the fact that succeeding measurements of root data have to be taken from separate plants, and they vary somewhat with the relative vigour of individual plants.

TABLE I.

Selected data of Root Growth of Perennial Ryegrass Control.

	9/4/34	8/6/34	28/6/34	7/8/34	9/10/34	3/2/35
Fresh wt. (grms.)	3.52	68.6	109.6	35.6	15.85	81.85
Dry wt. (grms.)	.354	12.05	24.1	14.6	4.4	25.49
Length (cms.)	28.9	78.0	70.5	70.0	64.0	50.0

Shoot growth—perennial rye-grass. Both fresh and dry weight of the shoot, and its length also, increase rapidly up to August 27th. From then they fall in weight and length. This is variously caused by the rotting of some of the leaves, shedding of seeds and breaking off of withered flower heads.

TABLE II.

Selected data of Shoot Growth of Perennial Ryegrass Control.

	9/4/34	8/5/34	8/6/34	27/8/34	6/10/34	3/2/35
Fresh wt. (grms.)	.958	60.4	101.0	175.0	99.8	93.25
Dry wt. (grms.)	.259	9.13	17.1	52.2	26.5	37.85
Length (cms.)	17.6	35.0	52.5	100.0	91.0	62.0
No. of tillers	14	123	182	251	—	—
No. of flowers	—	—	28	109	—	—

Root growth—timothy. Root growth in timothy is slower, and the maximum arrived at is lower than in perennial rye-grass. The behaviour of the root weight after the maximum is reached is a noteworthy feature, whereas in perennial rye-grass there is a sharp drop from 109.6 grams on June 28th to 35.6 grams on August 7th, and finally to 15.85 grams on October 6th the closing date, during the same period the fall in weight in timothy is only very slight, from 15.08 grams to 12.1 grams.

TABLE III.

Selected data of Root Growth of Timothy Control.

	9/4/34	19/5/34	18/6/34	17/8/34	6/10/34	3/2/35
Fresh wt. (grms.)	.108	7.372	15.08	13.53	12.1	12.4
Dry wt. (grms.)	.026	.884	2.08	3.79	2.55	3.75
Length (cms.)	12.6	49.5	58.5	85.0	38.0	42.0

Shoot growth—timothy. Growth rate as shown by the time taken for the maximum weight to be reached is slower than in perennial rye-grass. Perennial rye-grass reaches its maximum fresh weight of 175.0 grams in a little over four months, whereas maximum fresh weight of timothy shoot 113.4 grams is reached two months later. A point of considerable interest is revealed here. The maximum shoot weight of timothy is about two-thirds

the maximum shoot weight of perennial rye-grass. The relationship between these respective root weights is more, about one-seventh. The significance of this discrepancy is discussed later.

TABLE IV.

Selected data of Shoot Growth of Timothy Control.

	9/4/34	29/4/34	8/6/34	18/7/34	27/8/34	16/9/34	6/10/34	3/2/35
Fresh wt. (grms.)	.171	1.943	9.79	31.4	59.55	79.85	113.4	72.3
Dry wt. (grms.)	.012	.283	1.78	10.6	20.05	29.78	39.15	33.1
Length (cms.)	11	25	45	80	80	92	84	50
No. of tillers	2	6	14	38	65	78	82	—
No. of flowers	—	—	—	14	9	11	14	—

THE EFFECT OF CUTTING ON ROOT GROWTH.

Perennial rye-grass. Table V (p. 170) gives the fresh and dry weights of roots of plants cut under the various systems. The weight of the control roots are included.

It is obvious that all the types of cutting adopted check root growth but that the degree of checking depends on the severity of the cutting. Comparison of the maximum root weights of all the series gives an indication of the check. Those cut at ten day intervals lose weight over every interval from the first cut with no distinction between the respective maxima which are the original weight of root at the time cutting commenced. Those cut at thirty-day intervals show an increase in root weight depending on the intensity of the cut. The one inch cut series has a maximum root weight of 23.25 grams, which is reached after four intervals of thirty days. The half inch cut has a root weight maximum of only 5.52 grams fresh weight, but a quarter of the weight of the one inch set. The remaining series cut at ground level reaches a maximum of 0.99 grams fresh weight after only two months. All those cut at ten-day intervals and those of the thirty-day series cut at ground level are so severely treated that they died out before the end of the trial.

TABLE VI.

Maximum Root weight as percentages of the Root weight of Control—Perennial Ryegrass.

	Control.	*30 day interval cuts.*		
		1″ cut.	*½″ cut.*	*Ground level cut.*
Fresh root wt. (grms.)	109.6	23.25	5.52	0.99
Percentage	100%	21%	5%	0.9%

Timothy. Root growth is also checked in timothy, but apparently the checking action of cutting at ten-day intervals is

not as severe as in perennial rye-grass, for the roots show a rise in weight after cutting commences. The degree of checking is clearly shown in Table VIII.

It is to be observed in the control (Table VII, p. 171) that whereas the fresh weight of root reaches a maximum on June 18, the dry weights continue to rise from 2.08 grams on June 28 to 3.79 grams on August 17, and at the end of the experiment the fresh weight is 12.4 grams and the dry weight 3.75 grams.

TABLE VIII.

Maximum Root weights as Percentages of the Root Weight of Control—Timothy.

	Control.	10 Day Interval Cuts.			30 Day Interval Cuts.		
		One Inch Cut.	*Half Inch Cut.*	*Ground Level Cut.*	*One Inch Cut.*	*Half Inch Cut.*	*Ground Level Cut.*
Fresh wt. (gms.)........	15.08	0.45	.110	.204	4.605	2.20	.893
Percentage	100.0	2.9	7.2	1.3	30.5	13.9	5.9
Date	18/6/34	18/6/34	8/6/34	29/4/34	7/8/34	7/8/34	9/5/34

THE EFFECT OF CUTTING ON THE YIELD OF THE SHOOT.

Perennial rye-grass. Three factors in Table IX (p. 172) show clearly the final yields of each series, the distribution of yield, and the dry matter content.

Lateral comparison shows the effect of the length of the interval between cuts, whilst vertical comparison gives a clue to the effect of the intensity of cutting. The interval between the cuts proves to be the most important factor, greatly affecting the weight of yield and its dry matter content.

As far as distribution of yield is concerned, reference to Table IX (p. 172) shows that in the ten-day interval series, although a small amount of yield is contributed at each interval period, the greater part of the yield is given in the first few cuts, the remainder being almost negligible. For instance, in the one inch cut at ten-day interval the total yield of 6.118 grams fresh weight is given by twenty-one cuts over a period of six months, yet, of this yield 5.885 grams is given during the first ten cuts. Similarly, the half inch cut at ten-day intervals gives half its total yield in the first two cuts, whilst in the ground level cut three-quarters of the total yield is contributed by the first cut. Thus, apart from the very low yield in the grass cut at ten-day intervals, the distribution is limited over a short period and at the initial stages.

In the series cut at thirty-day intervals the yield is much greater and is distributed over a much wider period. For

example, the one inch cut provides 52.08 grams of its yield in five cuts or five months. The remaining cuts, which in the ten-day series are almost unproductive, produce 37.286 grams, an appreciable quantity of grass. Thus, increasing the interval has a three-fold action. It extends the productive period, increases the total yield, and increases the dry matter content of that yield. This last point is a factor which may tend to reduce palatability in the field, but an increase of only 3 per cent. in

TABLE X.

Yield and Dry Matter per cent for each treatment—Perennial Rye grass.

	10 Day Interval Cuts.		30 Day Interval Cuts.	
	Yield.	*Dry Matter %.*	*Yield.*	*Dry Matter %.*
One inch cut	6.113	14.9	89.366	17.3
Half inch cut	4.728	14.1	36.550	17.0
Ground level cut	2.060	14.7	8.801	21.1

dry matter content, as here, and any disadvantage it may have, is outweighed by the greater quantity of grass produced.

Timothy. The effects of the treatments as stated for yield in perennial rye-grass is true also of timothy. Cutting appears to affect the total yield per grass, the distribution, and the dry matter content of that yield (Table XI, p. 178).

TABLE XII.

Yield and Dry Matter percentage for each treatment—Timothy.

	10 Day Interval Cuts.		30 Day Interval Cuts.	
	Yield.	*Dry Matter %.*	*Yield.*	*Dry Matter %.*
One inch cut	1.104	19.4	15.118	24.6
Half inch cut	.718	19.7	5.819	35.4
Ground level cut	.136	21.3	1.413	19.8

A distinctive feature of timothy is its higher dry matter content. The percentage dry matter is affected to a greater extent than in perennial rye-grass. Extending the interval between the cuts raises the dry matter content of timothy very appreciably.

THE EFFECT OF CUTTING ON TILLERING AND FLOWERING.

Tillering. Tillering is reduced by cutting and is affected in much the same way as the other factors discussed. Cutting would be expected to increase tillering, at least in the initial stages, but a check is found at all stages and under all treatments.

TABLE XIII.

Maximum number of tillers.

	Tillers.	Date.	No. of tillers on control.
Perennial ryegrass.			
10 day interval cuts.			
Control	251	27/8/34	—
One inch cut	89	19/5/34	99
Half inch cut	47	9/5/34	123
Ground level cut	21	19/4/34	38
30 day interval cuts.			
One inch cut	117	7/8/34	143
Half inch cut	81	9/5/34	123
Ground level cut	44	9/5/34	123
Timothy.			
10 day interval cuts.			
Control	82	6/10/34	—
One inch cut	12	28/7/34	85
Half inch cut	7	29/5/34	18
Ground level cut	8	29/4/34	6
30 day interval cuts.			
One inch cut	40	7/8/34	67
Half inch cut	20	7/8/34	67
Ground level cut	9	7/8/34	67

Following on the production of maximum number of tillers some of the tiller members cease to be productive. Either they remain as dried-up stumps or they become over-moist and slough into decay. There is no evidence of increased tillering following cutting. Those tillers produced under the shorter rest period are very weak, and towards the end they appear as short very pale green shoots until finally no active tillers at all are produced. The only plants still producing tillers at the end of the experiment are the controls and those plants cut at one inch and half-inch heights at thirty-day intervals in both species.

Flowering.

The controls of both species flowered very abundantly. Perennial rye-grass commenced flowering on April 29th. By the end of the next ten day interval twenty-eight of the tillers produced inflorescences. The maximum number of flower heads counted on one plant was 109 on August 27th. Flower heads were slower in appearing in timothy. The first emerged on June 18th, and the greatest number produced was fifteen on August 17th.

None of the grasses undergoing cutting treatment flowered. One or two perennial rye-grass plants in the series cut at thirty

days were on the point of "shooting," and doubtlessly a lengthening of about five days in the interval between cuts would have sufficed to produce flower heads.

Shoot and Root growth in Perennial Ryegrass and Timothy.

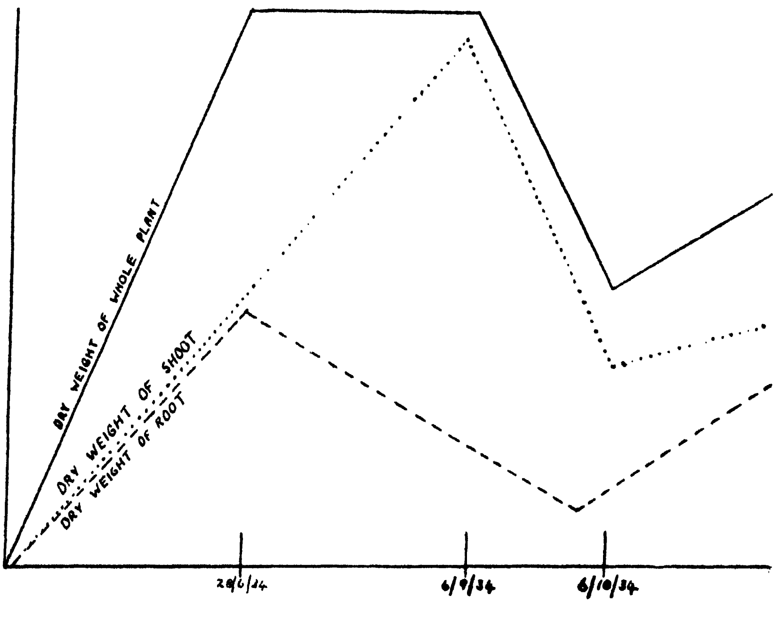
One of the most interesting observations that have emerged from this investigation is that the reserve food of perennial ryegrass is stored in the root. This conclusion is arrived at from a study of graphs of the weights of shoot and root, together with total weight of the plant in the controls, throughout the growing season.

Perennial Ryegrass:

As the data is drawn from weights taken not from one plant but from several plants arrested successively and at intervals throughout the season, a certain amount of fluctuation in the lines is inevitable. Sudden jumps reflect individual vigour or weakness in plants. In Diagram 1 such jerkiness has been eliminated. It is seen that both root and shoot grow equally for

DIAGRAM 1.

Growth of root, shoot and whole plant (dry weights) of perennial rye-grass control plants.



some time and up to about the middle of the flowering period. By then, some of the flowers are set and are making demands

for reserve food. From June 28th there is a sudden change of direction in the root line and in the total shoot growth line. From this date the root weight falls rapidly whilst the shoot weight rises equally rapidly, though the weight of the plant as a whole remains constant. The weight of the parts at this point are as follows :—

	28th June.
Dry weight root	24.10 grams.
Dry weight shoot	28.7 ,,
Dry weight whole plant	47.8 ,,
Number of flowers	15

The ratio of root to shoot is unity, indicating that both have grown at the same rate up to this point.

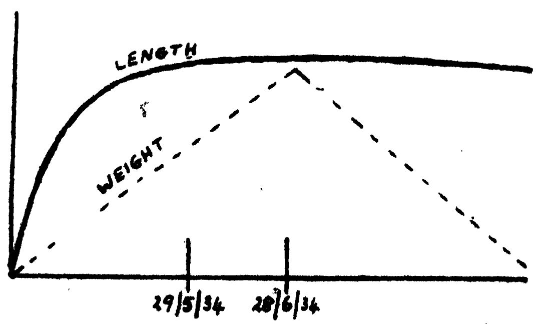
At the time of maximum shoot weight the same figures are :—

Dry weight root	12.7 grams.
Dry weight shoot	52.2 ,,
Dry weight whole plant	64.9 ,,
Number of flowers	109

The ratio of weights of root to shoot has now changed to 1 :4. In the meantime, the weight of shoot has advanced from 28.7 grams to 52.2 grams, a gain of 28.5 grams, whereas the total weight of the plant has advanced only by 15.1 grams (64.9—47.8). Over the same period there is a fall in weight of 11.8 grams (24.1—12.7) in the root. The further increase in shoot weight over and above the gain in weight of the whole plant for this period must then obviously be accounted for by transference of reserve material from root to shoot, the over plus of the one about balancing the loss in the other. Further evidence in support of this contention follows a study of the fluctuations in length and in weight of the roots of perennial rye-grass followed in time throughout the season.

DIAGRAM 2.

Length and weight of root—perennial rye-grass.

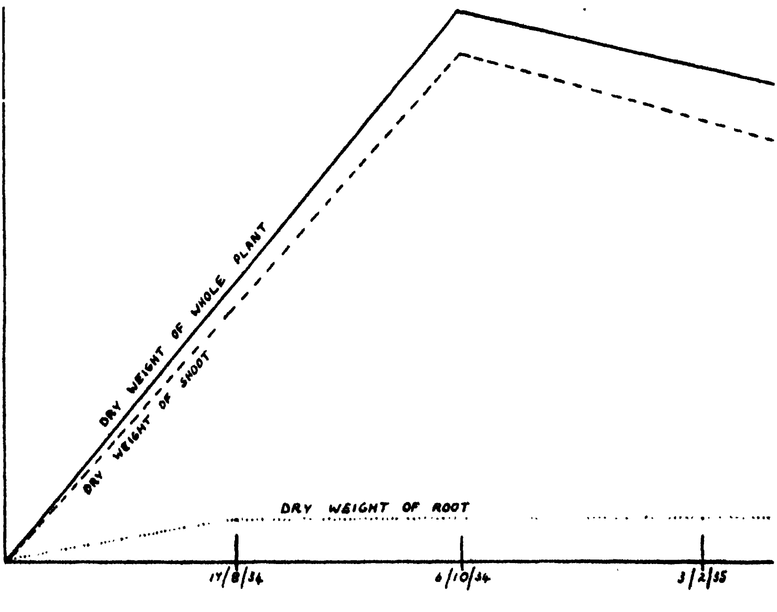


From Diagram 2 and the figures in Tables I—VIII it is seen that the roots attain maximum length some considerable time before they attain their maximum weights. Maximum length is maintained, but root weight steadily declines from its maximum once arrived at. During the lapse between reaching maximum length and maximum weight, *i.e.*, during June, the root is growing, not by putting on new cells, but by increase of cell contents, by the movement of food from the shoot system for storage in the root system.

Here also the minor fluctuations due either to extra vigour or lack of vigour in individual grasses have been smoothed out. With timothy the curves for both shoot weight and total plant weight are very closely related, showing a much more intimate relation between them than was the case in perennial rye-grass. The root has a very slow rate of growth, and its undulations are coincident with fluctuations in other curves and due to individual factors. In the main the root can be said to grow to a maximum weight and then to stop growing. There is no sudden fall in weight.

DIAGRAM 3.

Growth of root, shoot and whole plant (dry weights) of timothy control plants.



Any increase in growth of the whole plant is contributed to by the shoot portion alone. There is thus no movement of food between shoot and root systems. This is supported by the fact

that length and weight of root vary directly in timothy. They follow similar courses indicating that added weight in timothy roots is a function of added length or actual cell multiplication. One can conclude that no food reserve is stored in the roots of timothy.

The above follows from observations of the control plants, but data for the cut grasses clearly point towards it also.

TABLE XIV.

Selection of Root and Shoot Dry Weights (grams) at intervals through season.

Perennial Ryegrass.						
1″ at 10 day.						
	Date	9/4/34	19/4/34	29/4/34		
	Root	.354	.214	.132		
	Shoot	.259	.456	.685		
1″ at 30 day.						
	Date	9/4/34	9/5/34	7/8/34		
	Root	.354	.720	5.520		
	Shoot	.259	1.492	16.560		
Timothy.						
1″ at 10 day.						
	Date	9/4/34	19/4/34	29/4/34	19/5/34	18/6/34
	Root	.026	.019	.029	.056	.090
	Shoot	.012	.019	.083	.162	.362
1″ at 30 day.						
	Date	9/4/34	9/5/34	8/6/34	7/8/34	
	Root	.026	.130	.370	.949	
	Shoot	.012	.198	.987	4.970	

Table XIV gives a selection of root and shoot weights taken at intervals through the growing season for each of the grasses. The root of perennial rye-grass falls in weight, whilst the weight of shoot continues to increase. In the case of the series cut at thirty day intervals, extending the interval thus makes sufficient provision for some of the food, which has been withdrawn for replenishing lost foliage, to be replaced thus maintaining and actually increasing the root weight.

Timothy, under both intervals of cutting, does not show an immediate fall in root weight. Thus growth is not arrested by cutting. The roots continue to grow, even though the increase be only slight. At thirty days timothy behaves as at ten days, both root and shoot increasing in weight with no evidence at all of translocation of food.

Thus, under both these exhausting conditions of flowering and cutting of foliage there is loss in root weight in perennial rye-grass which is not evident in timothy.

Summary.

(1) *The effect of cutting on root growth.* Root growth is checked by all types of cutting. The amount of the check

depends on the severity of the cutting. The check on root growth is of three kinds :—

(*a*) Check in weight, as found in perennial rye-grass, due to removal of storage food from the root to the shoot, shown especially in the control at flowering time, and in the cut plants when the interval between cutting is so short that replacement of storage food is not possible.

(*b*) Check in actual growth, shown by the decreased length of root in perennial rye-grass and by decreased length and weight of root in timothy.

(*c*) Seasonal check in growth rate as shown by the controls of both species.

(2) *The effect of cutting on shoot yield.* This is seriously affected both by varying the level at which cuts are made and by the frequency of cutting. The most lenient type of cutting produces in both species the greatest yield. With the extension of the interval between cuts enhanced yields of dry matter are obtained.

(3) *The nature of the storage organ.* This, in perennial rye-grass, is shown to be in the root system. Further investigation is needed before its exact position in the root system can be established. The fact that the reserve food is in the root system in perennial rye-grass has not previously been established, but a collateral precedent for it in cereals has been suggested by Brenchley and Jackson (1) in the terms " Certain ' white roots ' or thick unbranched roots in wheat and barley may be stores of reserve food."

The location of the storage tissue may be a deciding factor in the persistence or otherwise of a grass species under conditions of heavy and frequent grazing. Practical experience in North Wales shows that timothy quickly disappears from pastures under conditions of heavy grazing, particularly when this is practised in late winter or early spring (4*a*). Perennial rye-grass withstands very heavy grazing, and has remarkable persistency.

This established difference of persistence may be ascribed, in view of the above, to the difference in the position of the storage organ in the two species; that of perennial rye-grass is safely below ground, whilst timothy has a more exposed storage organ in the bulbous shoot base.

TABLE V.

Fresh and Dry Weights of Roots of Perennial Rye-grass under the various systems of cutting and for the controls.

DATE.	CONTROL.		10 DAY INTERVAL CUTS.						30 DAY INTERVAL CUTS.					
			One Inch Cut.		*Half Inch Cut.*		*Ground Level Cut.*		*One Inch Cut.*		*Half Inch Cut.*		*Ground Level Cut.*	
	Fresh.	*Dry.*	*Fresh.*	*Dry.*	*Fresh.*	*Dry.*	*Fresh.*	*Dry.*	*Fresh.*	*Dry.*	*Fresh.*	*Dry.*	*Fresh.*	*Dry.*
9/4/34	3.52	.354	3.520	.354	3.520	.354	3.52	.354	3.520	.354	3.520	.354	3.520	.354
19/4/34	5.72	.575	2.084	.214	1.857	.191	2.00	.240	—	—	—	—	—	—
29/4/34	10.59	1.101	1.125	.132	.695	.099	.35	.036	—	—	—	—	—	—
9/5/34	22.77	4.070	2.013	.274	1.204	.161	.465	.099	6.270	.720	5.580	.590	2.550	.295
19/5/34	23.06	2.830	1.750	.260	.665	.108	.258	.056	—	—	—	—	—	—
29/5/34	—	4.400	.480	.070	.225	.032	.056	.010	—	—	—	—	—	—
8/6/34	68.60	12.050	.580	.080	.400	.050	.010	—	7.400	1.14	2.440	.310	.990	.440
18/6/34	50.90	9.640	1.165	.220	.375	.070			—	—	—	—	—	—
28/6/34	109.60	24.100	.897	.171	.090	.019	Death of grasses.		—	—	—	—	—	—
8/7/34	—	—	—	—	—	—			—	—	—	—	—	—
18/7/34	24.20	10.140	.610	.140	.267	.060			—	—	—	—	—	—
28/7/34	37.10	9.830	.198	.050	.158	.042			—	—	—	—	—	—
7/8/34	35.60	14.600	.132	.043	.112	.029			23.25	5.52	4.08	1.049	.498	.146
17/8/34	25.00	5.700	.033	.013	.129	.036			—	—	—	—	—	—
27/8/34	21.32	12.700	.058	.015	.141	.041			—	—	—	—	—	—
6/9/34	28.00	12.030	.105	.030	—	—			7.21	1.36	2.92	.856	.253	.083
16/9/34	21.60	5.230	Death of grasses.		.097	.037			—	—	—	—	—	—
26/9/34	—	—							—	—	—	—	—	—
6/10/34	15.85	4.400			Death of grasses.				9.90	2.30	2.10	.520	—	—
5/11/34	—	—							5.00	1.37	3.46	.940	.130	.045
5/12/34	—	—							—	—	—	—	Death of grasses.	
4/1/35	—	—							2.59	.59	1.34	.360		
3/2/35	31.38	25.49							3.20	.874	.24	.100		

TABLE VII.

Fresh and Dry Weights of Roots of Timothy under various systems of cutting and for the controls.

Date.	Control.		10 Day Interval Cuts.						30 Day Interval Cuts.					
			One Inch Cut.		*Half Inch Cut.*		*Ground Level Cut.*		*One Inch Cut.*		*Half Inch Cut.*		*Ground Level Cut.*	
	Fresh.	*Dry.*	*Fresh.*	*Dry.*	*Fresh.*	*Dry.*	*Fresh.*	*Dry.*	*Fresh.*	*Dry.*	*Fresh.*	*Dry.*	*Fresh.*	*Dry.*
9/4/34	.108	.026	.108	.026	.108	.026	.108	.026	.108	.026	.108	.026	.108	.026
19/4/34	.326	.038	.140	.019	.130	.021	.084	.012	—	—	—	—	—	—
29/4/34	1.477	.128	.232	.029	.220	.025	.204	.039	—	—	—	—	—	—
9/5/34	1.454	.100	.341	.053	.175	.022	.009	.007	1.108	.130	1.333	.147	.893	.088
19/5/34	7.372	.884	.424	.056	.153	.025	.006	.001	—	—	—	—	—	—
29/5/34	7.120	.796	.160	.024	.426	.048	.004	.003	—	—	—	—	—	
8/6/34	2.710	.360	.420	.050	1.100	.140	.090	.010	2.420	.370	.980	.130	.095	.020
18/6/34	15.080	2.030	.450	.090	.323	.065	.005	.003	—	—	—	—	—	—
28/6/34	11.300	2.305	.275	.051	.155	.025	Death of grasses.		—	—	—	—	—	—
8/7/34	—	—	—	—	—	—			—	—	—	—	—	—
18/7/34	11.066	2.690	.117	.028	.115	.035			—	—	—	—	—	—
28/7/34	8.883	1.915	.160	.047	.039	.011			—	—	—	—	—	—
7/8/34	13.063	3.026	.090	.033	—	—			4.605	.949	2.100	.458	.115	.100
17/8/34	13.530	3.790	.085	.021	.052	.014			—	—	—	—	—	—
27/8/34	3.715	.783	.037	.010	.063	.021			—	—	—	—	—	—
6/9/34	3.732	1.020	.033	.010	.073	.020			3.512	.665	1.190	.315	Death of grasses.	
16/9/34	4.780	2.520	.007	.003	.007	.004			—	—	—	—		
26/9/34	—	—	—	—	—	—			—	—	—	—		
6/10/34	12.100	2.550	.066	.024	.030	.010			1.370	.320	.610	.160		
5/11/34	—	—	Death of grasses.						1.400	.270	.220	.060		
5/12/34	—	—							—	—	—	—		
4/1/35	—	—							1.750	.490	—	—		
3/2/35	12.400	3.750							.200	.110	.090	.040		

TABLE IX.

Total Yield to date per Grass. Fresh and Dry Weights of Perennial Rye-grass.

Date.	10 Day Interval Cuts.						30 Day Interval Cuts.					
	One Inch Cut.		*Half Inch Cut.*		*Ground Level Cut.*		*One Inch Cut.*		*Half Inch Cut*		*Ground Level Cut.*	
	Fresh.	*Dry.*	*Fresh.*	*Dry.*	*Fresh.*	*Dry.*	*Fresh.*	*Dry.*	*Fresh.*	*Dry.*	*Fresh.*	*Dry.*
9/4/34	.988	.150	1.391	.207	1.520	.227	1.090	.159	1.428	.212	1.438	.207
19/4/34	2.024	.293	2.377	.331	1.868	.270	—	—	—	—	—	—
29/4/34	2.795	.404	2.947	.400	1.964	.283	—	—	—	—	—	—
9/5/34	3.790	.549	3.497	.480	2.000	.290	11.510	1.547	8.480	.999	4.593	.652
19/5/34	4.562	.646	3.917	.532	2.017	.293	—	—	—	—	—	—
29/5/34	5.158	.727	4.207	.572	2.031	.295	—	—	—	—	—	—
8/6/34	5.569	.798	4.407	.605	2.040	.297	28.710	4.407	18.280	2.585	7.243	1.441
18/6/34	5.742	.832	4.507	.625	2.053	.300	—	—	—	—	—	—
28/6/34	5.874	.849	4.559	.636	2.060	.303	-	—	—	—	—	—
8/7/34	5.885	.862	4.564	.643	Death of grasses.		37.550	7.340	20.685	3.941	7.617	1.680
18/7/34	5.910	.870	4.583	.649			—	—	—	—	—	—
28/7/34	5.946	.878	4.667	.655			—	—	—	—	—	—
7/8/34	5.987	.886	4.693	.659			52.080	9.847	26.982	4.798	8.228	1.751
17/8/34	6.014	.890	4.709	.664			—	—	—	—	—	—
27/8/34	6.032	.894	4.719	.666			—	—	—	—	—	—
6/9/34	6.041	.898	4.724	.668			67.630	12.513	31.833	5.591	8.572	1.813
16/9/34	6.055	.904	4.726	—			—	—	—	—	—	—
26/9/34	6.075	.907	4.727	—			—	—	—	—	—	—
6/10/34	6.093	.911	4.728	—			81.108	14.213	35.433	6.096	8.727	1.833
16/10/34	6.103	.914	Death of grasses.				—	—	—	—	—	—
26/10/34	6.113	.916					—	-	—	—	—	—
5/11/34	Death of grasses.						88.003	15.204	36.315	6.216	8.794	1.849
5/12/34							88.963	15.431	36.475	6.221	8.807	1.851
4/1/35							89.363	15.492	36.550	6.231	Death of grasses.	
3/2/35							89.366	15.494	Death of grasses.			

TABLE XI

Total Yield to date per Grass. Fresh and Dry Weights of Timothy.

DATE.	10 DAY INTERVAL CUTS.						30 DAY INTERVAL CUTS.					
	One Inch Cut.		*Half Inch Cut.*		*Ground Level Cut.*		*One Inch Cut.*		*Half Inch Cut.*		*Ground Level Cut.*	
	Fresh.	*Dry.*	*Fresh.*	*Dry.*	*Fresh.*	*Dry.*	*Fresh*	*Dry.*	*Fresh,*	*Dry.*	*Fresh.*	*Dry.*
9/4/34	.051	.012	.087	.019	.102	.024	.069	.012	.089	.015	.134	.022
19/4/34	.130	.025	.165	.030	.118	.026	—	—	—	—	—	—
29/4/34	.213	.041	.220	.041	.126	.027	—	—	—	—	—	—
9/5/34	.362	.069	.291	.055	.128	.028	1.034	.177	.871	.144	.457	.073
19/5/34	.519	.093	.370	.068	.130	.028	—	—	—	—	—	—
29/5/34	.684	.122	.462	.082	.132	.029	—	—	—	—	—	—
8/6/34	.826	.147	.539	.086	.134	—	4.285	.730	2.581	.790	.882	.150
18/6/34	.909	.166	.600	.099	.136	—	—	—	..	..	..	..
28/6/34	.951	.175	.630	.107	Death of grasses.		—	—	..	..	..	..
8/7/34	.967	.184	.634	.113			6.560	1.990	3.361	1.347	.994	.202
18/7/34	.987	.190	.653	.119			—	—	—	—	—	—
28/7/34	1.015	.197	.671	.123			—	—	..	..	..	..
7/8/34	1.036	.202	.680	.126			10.005	2.583	4.724	1.824	1.260	.246
17/8/34	1.052	.204	.687	.130			—	—	..	..	..	..
27/8/34	1.068	.205	.693	.134			—	—	—	—	—	—
6/9/34	1.076	.207	.696	.136			12.970	3.224	5.344	1.967	1.395	.273
16/9/34	1.085	.210	.701	.138			—	—	—	—	—	—
26/9/34	1.093	.212	.708	.139			—	—	—	—	—	—
6/10/34	1.097	.213	.712	.140			14.089	3.459	5.596	2.018	1.402	.280
16/10/34	1.102	.214	.716	.141			—	—	..	..	..	..
26/10/34	1.104	.215	.718	.142			—	—	—	—	—	—
5/11/34	Death of grasses.						14.689	3.581	5.736	2.049	1.413	.281
5/12/34							14.981	3.633	5.797	2.058	Death of grasses.	
4/1/35							15.051	3.666	5.817	2.063		
3/2/35							15.118	3.728	5.819	2.064		

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VEGETATIVE VIGOUR AND THE POSSIBILITY OF NATURAL CROSS-FERTILISATION IN SOFT BROME, *BROMUS HORDEACEUS* L. (*B. MOLLIS* L).

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The inquiry into the relationship between flowering and seed-setting in the grasses had not long been under investigation when the question was asked, "Are progenies derived from free-flowering panicles of soft brome more vigorous than those from protected (selfed) panicles?" At the time no answer, based upon quantitive data, was possible.

Godron (1878, p. 128) considered that in this species (his *Serrafalcus mollis* Parl.) fertilisation was "direct" within slightly opened paleae. This is probably to be interpreted to

mean that self-fertilisation is the normal, if not the exclusive, method here. In such a case then, apart from rare inter-fertilisation when some access of vigour might occur as a result of heterosis, no significant differences could be anticipated when plants derived from the seeds of protected and unprotected inflorescences were compared.

An experiment was therefore set up to test whether, in fact, significant differences occurred between the green weight yields of such plants. Seeds were harvested from free-flowering and protected panicles from among a number of grouped plants flowering together in a greenhouse. As the plants were derived from three different sources there was every opportunity for cross-pollination and fertilisation if such were at all possible.

The results which follow are based upon the green-weight yields of 320 individual plants from enclosed and 320 from free panicles, each of the sixteen families being represented by 20 La[1] and 20 Lc[1] progeny plants.

The seeds were sown in boxes during the third week of March, 1928, and transferred to their positions in the field in June.[2] All the plants continued in the vegetative state until May, 1929, when the production of panicles occurred quite normally.

The plants in each family were cut back as uniformly as possible, during dry weather, at approximately the zenith of flowering. The green produce cut from each plant was then immediately weighed, after which the material was returned to its own basket and the shoots were subsequently separated and counted.

Some of the plants continued to send up new panicle shoots, necessitating a second cut, which was carried out six weeks after the first. If the initial cut had been delayed a week or two it is probable that the majority, if not all, of the plants would then have completed their life-cycle and made no further growth.

Observational notes made on the plants three months after transplanting show that the general level of vigour in the La and Lc progenies was approximately equal for most of the families. In the case of family 404, however, the La was even then clearly the more vigorous.

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1 The seed from protected (selfed) panicles, as well as the progenies derived from them, will for convenience be represented in this paper by the symbol La, and those from free panicles by Lc. These symbols as normally employed at the Welsh Plant Breeding Station denote, respectively, progenies from selfed and open-pollinated inflorescences of cross-fertile species such as rye-grass or cocksfoot.

2 This unusually long period in the boxes was necessitated by the late spring drought making delay in the transplanting of seedlings inevitable.

TABLE I, gives (1) the number of plants falling within each green weight class (10 gm. increments). (2) the total green weight and (3) various statistical measures for the La and Lc progenies of each of the sixteen families of soft brome. (Plants weighing 30 gm. or less grouped together).

Family.	*Progeny.*	*Green Weight Classes (Upper Limits).* 0–30	40	50	60	70	80	90	100	110	120	130	140	*Total green weights. (gm.).*	*Means ± standard error.*	*Difference between means ± standard error of difference.*
391	La	20	0	0	0									272	13.60 ± 1.99	1.70 ± 3.76
	Lc	16	1	2	1									305	15.25 ± 3.93	
392	La	20	0											205	10.25 ± 0.96	2.20 ± 2.93
	Lc	18	2											249	12.45 ± 2.77	
393	La	20	0											186	9.30 ± 1.48	0.95 ± 2.11
	Lc	20	0											215	10.75 ± 1.51	
395	La	11	3	4	1	1								582	29.10 ± 3.68	3.25 ± 5.55
	Lc	8	2	7	2	1								647	32.35 ± 4.15	
396	La	20	0											193	9.65 ± 1.26	0.60 ± 1.95
	Lc	20	0											181	9.05 ± 1.49	
397	La	7	8	5	0									588	29.40 ± 3.23	2.55 ± 4.43
	Lc	10	2	7	1									639	31.95 ± 3.03	
399	La	8	4	0	2	5	1	0	0					740	37.00 ± 5.68	2.80 ± 8.48
	Lc	8	1	3	3	2	1	1	1					796	39.80 ± 6.29	
400	La	19	1											222	10.10 ± 2.11	3.00 ± 3.13
	Lc	19	1											282	14.10 ± 2.31	
401	La	2	2	5	8	2	0	1	0	0	0			973	48.65 ± 3.55	7.40 ± 7.27
	Lc	4	3	1	4	2	2	1	2	0	1			1121	56.05 ± 6.35	
402	La	10	2	5	1	0	0	2	0	0	0	0	0	695	34.75 ± 4.69	9.20 ± 8.78
	Lc	9	0	1	4	4	1	0	0	0	0	0	1	879	43.95 ± 7.42	
403	La	4	2	2	2	5	3	0	0	1	0	1		1091	54.55 ± 6.57	19.05 ± 9.43
	Lc	2	1	0	3	3	2	3	1	2	2	1		1472	73.60 ± 6.77	
404	La	11	4	4	1									603	30.15 ± 3.08	12.25 ± 4.10
	Lc	17	2	1	0									358	17.90 ± 2.70	
405	La	6	3	2	2	2	1	1	3	0				966	48.30 ± 6.95	5.70 ± 8.61
	Lc	3	1	5	4	3	2	1	0	1				1080	53.80 ± 5.09	
406	La	4	3	4	2	1	3	1	2	0	0			1049	52.45 ± 5.52	11.90 ± 7.91
	Lc	10	1	3	2	1	2	0	0	0	1			811	40.55 ± 5.66	
407	La	11	0	2	3	2	2	0						707	35.35 ± 5.28	6.60 ± 7.30
	Lc	5	3	4	4	3	0	1						839	41.95 ± 5.04	
408	La	8	2	5	0	2	3	0	0	0	0	0		808	40.40 ± 4.96	15.65 ± 9.21
	Lc	6	1	4	2	1	3	0	0	1	1	1		1121	56.05 ± 7.76	
Totals ..	320 La plants	80	34	38	22	20	13	5	5	1	0	1	0	9880	30.87 ± 1.38	3.49 ± 2.22
	320 Lc plants	82	21	38	30	20	13	7	4	4	5	2	1	10,995	34.36 ± 1.07	

A comparison of the yield data shows that the Lc lots surpassed the La's in thirteen of the sixteen families (see Table I). This superiority is also reflected in the total yields, the former gave 10,995 grammes, compared with 9,880 grammes by the latter. A fairly detailed comparison of the nature of the progenies from each mother-plant is possible in Table I, where the plants are shown grouped in weight classes of 10 gm. increments.

Statistical analyses, based on the theory of normal distribution, show that the differences in yields between the La and Lc lots of each family are not to be regarded as significant. This is also the conclusion arrived at from the application of Fisher's test for the significance of the means of small samples, to the total weights for each family, since a value of $t = 1.74$ for $n = 15$ gives $P = 0.1$ (see Fisher, 1932, p. 112).

The plants in this experiment were not examined for any possible occurrence of segregation of morphological characters.

Consideration of the progeny yields in Table I shows that the plants from unprotected panicles have produced a greater number of individuals of outstanding weight than their counterparts from enclosed heads.

The actual and relative weights for the heaviest La and Lc plants in each family are shown in Table II.

TABLE II.

The heaviest plant in each La family; those heavier than it in the corresponding Lc family (or the heaviest Lc plant where the La is the heavier), together with the weights of the Lc plants relative to those of the La's put at 100.

Family.	*Heaviest La gm.*	*Heavier (or the heaviest) Lc gm.*	*Lc relative to La's = 100.*
391	29	33, 42, 47 and 59	114, 145, *162*, *203*
392	25	38, 39	*152*, *156*
393	23	27	117
394	61	66	108
396	20	23, 24	115, 120
397	46	47, 50, 53	102, 108, 115
399	74	88, 96	119, 130
400	40	33	82
401	83	96, 97, 119	116, 117, 143
402	83	135	*163*
403	122	124	101
404	53	50	94
405	100	102	102
406	98	115	117
407	78	87	111
408	78	101, 118, 124	130, *151*, *159*

In only two of the families (400 and 404) did the weight of every Lc plant fall below that of the best La. An examination

of the relative weights (last column) shows that in the case of occasional Lc individuals the advantage in their favour is considerable. Thus families 391, 392, 402 and 408 contain plants which are over 50 per cent., and in one case 100 per cent., heavier than the best corresponding La.

The panicle shoot number data, as might be expected in a winter annual, bear a very close resemblance to those of the weight data. The Lc's produced more shoots in twelve of the sixteen families, while in the grand totals the figures were 22,115 as against 20,828 for the La's. Only 151 and 111 from each group were not definitely classifiable as panicle shoots; these, on account of their small size, had to be classified as non-panicle shoots, although they were in all probability potential panicle producers.

A number of plants from the above experiment were selfed and in the case of three (one from each La lot of families 392, 401 and 403) La and Lc seed was sown in February, 1930, and planted out in May. At the zenith of flowering in the following year, each of the seventy-five La and Lc plants was cut back and weighed. The results are interesting because the Lc's here have given lower yields than the La's, and further, the yields from each of the progenies *as a whole* appear to bear a direct relationship to that of the parent plant. The actual figures were :—

		(a)	(b)	(c)
Weight of mother plant (cut 1929)	....	15	53	68 gm.
Weight of 75 La plants (cut 1931)	....	2,091	3,746	4,661 gm.
Weight of 75 Lc plants (,, ,,)	....	1,845	3,514	4,081 gm.

The type of variation within each lot is similar to that found in the families from which the parents were drawn, except that the range is wider in the second generation plants. The frequency distribution for the La and Lc lots of the various families as a whole lacks symmetry and also tends to be bimodal in character.

Discussion.

The comparison of aggregate yields calls for no detailed discussion, since it is clear that there is no significant difference between plants raised from seed produced by self-pollination under controlled conditions, and those raised from seed produced in the normal way. The mode of flowering described by Godron and confirmed by Beddows (1931, p. 35) suggests that the situation in regard to pollination in soft brome is analogous to that in wheat or oats. This view may be said to have been confirmed, in a general way, by the quantitative data obtained (Table I).

The results are, at the same time, particularly interesting

because of the fact that within each family of plants, however derived, there is a very wide range of variation in bulk. The data given in Table I showed that in two families (393 and 396) no plants weighed more than 30 gm., whereas in some of the other families (401 and 403 for example) the majority did so. The variation in weight from plant to plant was, however, of the same order in families of low total weight as in the others, that is to say, it is not confined to the heavier yielding families.

Observations on this species, under single plant cultivation, do not point to this variation being due, except partially, to soil heterogeneity. We must therefore consider the other possible causes.

The size of the seed from which a plant develops has been shown by Brenchley (1923, p. 239), Jones and Tincker (1926, p. 541) and others, to be of considerable importance in inducing good initial and subsequent development, especially in the case of short-lived crops, and this may have had some effect in the soft bromes. It is, however, difficult to see that size of seed, even in conjunction with soil heterogeneity, would be sufficient to give the very wide range met with. In fact the range strongly suggests some kind of segregation for vigour, but such segregation would not be expected to be so constant a feature in a normally self-pollinated species.

It is, therefore, necessary at this point to consider the evidence for natural cross-fertilisation in normally self-fertilising species. The position with regard to wheat has been summarised by Jenkin (1925, p. 104). He found that for the old Welsh land variety, *Hen Gymro*, the amount of natural crossing under field conditions was variable (between 1 and 10 per cent.), but never to be regarded as negligible even under adverse weather conditions. In oats, Jones (1933, p. 115) found that natural crossing occurred between black and white varieties to the extent of 0.1 per cent of the total individual plants examined (115,920 plants), while in respect of head-rows, in alternate drills of black and white oats, crossing was observed in 10 per cent. of the rows. Both Jenkin and Jones found certain varieties to be more prone to natural crossing than others.

A case of cross-fertilisation occuring in a normally self-(autogamously) fertilised perennial species is furnished by Western rye-grass (*Agropyron tenerum* Vasey.), a native of North America. It is stated by Kirk (1929) that both he and McRostie found that " in the main the progenies of single plants are true-breeding, but occasionally segregation occurs, indicating

that some plants are heterozygous for one or more characters. It is evident, therefore, that some natural crossing takes place."

In the case of *B. hordeaceus*, Beddows (*loc. cit.*, p. 88) expresses the opinion, based on a fairly extensive experience of the flowering habits of soft brome, that "cross-pollination (xenogamy) may not be impossible." Again, Holmberg (1934, p. 324) collected what he regarded as unmistakable examples of hybrids between *Bromus hordeaceus* and *Bromus mollis*,[3] while Nilsson (1931) reports that he has experimentally reproduced the hybrid from reciprocal crosses between these two "species." The hybrids obtained presented characteristics intermediate between those of the parents. They gave apparently normal pollen and relatively good seed yields, so he anticipated segregation in the following generations.

It is therefore quite conceivable that the extreme bulky Lc plants of the present experiments were the direct result of natural crossing, but since some plants, almost as bulky, were also recorded in La families, this cannot be the only cause of high vigour. In all probability the plants of soft brome are usually heterozygous for factors concerned with plant vigour. It is clear from the data given that, on the average, different families have different ranges (see Table I), and further that individual plants have a definite effect upon the aggregate yield of their progenies. Thus natural crossing might be expected in the first instance to give heterosis, while in later generations there would be some kind of segregation (*cf.* Nilsson *loc. cit.*).

The general occurrence of wide variations suggests, despite the fact that self-pollination is not only possible but probably normal in soft brome, that cross-fertilisation occurs sufficiently often to keep the general populations in a state of heterozygosity.

The question of time of sowing, and its relation to the period elapsing before the stage of maximum inflorescence production is reached (in annuals the completion of their life-cycle) is of considerable interest in the Gramineæ.

Jenkin (1935, p. 395), in the course of his investigations on the inter-relationships of *Lolium perenne* and *L. temulentum* found in the case of Darnel grass (an annual) "that if seed is sown sufficiently early in the season, a particular strain of *L. temulentum* will not vary very appreciably in the time of the

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[3] Holmberg, largely as a result of his studies of these hybrids, raised both *B. hordeaceus* and *B. mollis* to specific rank (see also Holmberg 1926, p. 262), and this has also been done by Hitchcock (1935, p. 50). On the other hand Ascherson and Graebner (1902, p. 615), and systematists generally in Britain, do not at present subscribe to this classification, both names being regarded as synonyms covering closely related variable forms.

year when it reaches the flowering stage, provided other growth conditions are as uniform as the season of the year will allow." In the case of *L. perenne*, with its very wide differences in type, he found that seed sown in the early autumn will produce plants reaching full maturity in the following season. If, however, sowing was delayed until the spring, then even early flowering types would not reach full maturity during that season, although they might produce a relative abundance of inflorescences in the autumn.

Results of a comparable nature were met with in soft brome, since seed of this species sown in March of 1928 and 1930 respectively developed into plants which failed to complete their life-cycles in one growing season. On the other hand, seed sown towards the end of January, 1927, resulted in plants which were in full flower before the end of June. Those of 1928 and 1930 were not only sown later, but they also had to remain in their seeding boxes until June and May respectively, and it was thought that this combination of circumstances, together with the check to growth at transplanting, caused the seedlings to remain in the vegetative stage. Subsequent experience with a number of annual grasses makes it reasonably certain that the various species have a different (or possibly a range of different) critical sowing dates; any seed sown at dates beyond these will not proceed to the production of flowering shoots until the following growing season. This is probably a photoperiodic effect produced on long day plants by the reduction in the hours of daylight after midsummer. Tincker (1925, p. 730) found that oats sown on the first day of February, and from that date onwards, exposed to daylight for six to nine hours *per diem* only, either produced no panicles at all or but very few, which did not emerge until a long time after those of the controls.

Summary.

1. Progenies from selfed and free-flowering panicles of soft brome were compared by means of their green-hay weights. Those from selfing were, on the whole, less vigorous, but the differences were not statistically significant.

2. The different families, irrespective of origin, all showed very wide variations in the vigour of the individual plants. These variations are discussed in relation to soil heterogeneity, size of seed and segregation.

3. Natural crossing is suggested as the cause of the exceptionally vigorous plants occasionally found among the progenies derived from free-flowering panicles of soft brome.

4. Three examples are given in which the relative vigour of the mother plants is strongly reflected in the total yields of the following generation.

5. Seed of the winter annual, soft brome, must be sown before its critical sowing date (the latter part of March appears to fall after this) if the plants are to complete their life cycle in the same growing season. This is probably a photoperiodic effect.

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EXPERIMENTS ON THE USE OF LIME IN CONTROLLING FINGER AND TOE DISEASE OF BRASSICAE.

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Introduction.

The very large number of field trials carried out over the last fifty years have fully established the usefulness of liming as a soil treatment against finger and toe (clubroot) disease. Although recent work (1.2.3) has shown that mercuric perchloride rivals lime in efficiency for such crops as cabbage and its allies, and the use of resistant swede varieties (4.5.6) is now accepted as a valuable supplement to lime, there is little doubt that this latter treatment will continue to be used both for disease control and its general ameliorative effect on soils.

The published accounts of liming trials, however, clearly indicate that the object was considered to be attained when reasonable control was achieved with some one form of lime. It is rare to find any statement as to soil texture or acidity, and usually no effort is made to compare the results of similar dressings on soil differing in degree of contamination or buffer power. This lack of comparable data seriously impedes advisory work as can be seen from the fact that eight standard reference books give the following dressings of quick lime per acre as greatly reducing finger and toe—35 bushels, 150 bushels, 2 tons, "up to 4 tons," 3 to 4 tons, 1 to 1½ tons if disease is slight and 3 to 4 tons if bad, 5 to 7 tons, 8 tons. All, however, agree that "acid" soils favour disease development and alkaline conditions partially or wholly inhibit it; and there is also agreement in stating that to be effective the lime should be applied some months prior to sowing the susceptible crop.

A definite advance in the technique of the older experiments was made in the trials carried out at Craibstone from 1916 onwards by the North of Scotland College of Agriculture (7). Here the "lime deficiency" of the soil was determined (presumably by the Hutchinson MacLennan method), and each year until 1919 lime was applied in excess of that required to make up the deficiency; the amount varying from 23 cwt. to 34 cwt. per acre. These trials are also of interest in that whilst this method gave fair control on badly contaminated soil carrying turnips without rotation, much heavier dressings (5 and 10 tons per acre) effected little, if any, improvement in other trials in which it is clear from the percentage given that the soil was only

slightly contaminated. It is indeed a general experience that dressings of lime which are efficacious in one trial are quite inadequate in others and it is obvious that the essential relation between lime and control of finger and toe remains to be discovered. The growing appreciation that it was the activity of the acid ions in the soil rather than the total acid content which was important, led Atkins (8) in 1922 to compare the pH of clean soil with that of soil contaminated with finger and toe, and to arrive at a tentative conclusion that the organism could not exist when the pH reached the neighbourhood of 6.7. The most complete study of soil reaction in relation to the control of finger and toe was that of Chupp (9) in trials carried out in U.S.A. during 1928. This writer came to the definite conclusion that at a pH of 7.2 to 7.4 the organism was incapable of causing infection. It remained to be seen whether Chupp's conclusions could be confirmed under the conditions of North Wales and it was partly with this object in view that the present writer laid down trials in 1933.

The Problem and "Lay-out" of Trials.

It appeared to the present writer that information was urgently needed on the following points if advice on the effective use of lime in controlling finger and toe disease was to be given to growers.

(1) The changes in pH in contrasting soil types as affected by lime.

(2) Whether similar pH reaction effected similar control—thus pointing to indirect action only on the part of lime.

(3) Whether similar applications of lime effected similar control of finger and toe—thus indicating a direct lethal action on the spores.

(4) Comparison of the *residual* effect of a small application of lime as against the *immediate* effect of a large dressing.

(5) Whether any definite grading in susceptibility was possible with the different brassicae commonly grown.

(6) What minimum dressing of lime was required to effect a reasonable degree of control with different brassicae on contrasting types of soil.

Two centres were chosen, at Pwllheli and Bangor respectively, in which the soil, whilst being heavily contaminated with the finger and toe organism, showed considerable contrasts in

texture, and pH reaction, these differences being brought out in Table I.

TABLE I.

Soil Conditions at Two Centres.

	Pwllheli.	*Bangor.*
Coarse Sand	36.0	19.0
Fine Sand	31.0	26.0
Silt	15.5	21.0
Clay	10.5	23.2
Organic matter	5.37	5.71
pH reaction	5.25	7.24
Exchangeable CaO	0.076	0.41

The writer is indebted to the Agricultural Chemistry Department of this College, and in particular to Mr. D. O. Hughes, M.Sc., for the soil analysis and potentiometric determinations of pH reaction.

Four trials in all were laid down, two at each centre. At Pwllheli the two trials differed in one having received a uniform dressing of two tons of ground lime the previous year, whilst at Bangor one of the two trials was on land with impeded drainage. Each of the four trials consisted of thirteen plots (1/16 acre each at Pwllheli and 1/33 acre at Bangor), of which ten were dressed, in duplicate, during the early spring of 1933 with ground lime (CaO) at the rate of two, four, six, eight, and ten tons per acre respectively. A plot at each end and one in the centre received no lime and acted as untreated controls. During the three years 1933-35, crops of cauliflowers, cabbages (green, red and savoys) and brussel sprouts were grown on all plots at Pwllheli, whilst at Bangor the only variation was that swedes replaced red cabbages. The percentage roots slightly, moderately, and badly attacked with finger and toe was taken each autumn and the changes in pH reaction of each plot were determined each autumn (November and December) and early summer (April and May).

It was known that some lime had been applied on the Bangor plots during the winter of 1931-32, before the trials were laid down, but there was ample proof that the disease was severe in the following year. Unfortunately it became evident during the progress of the work at this centre that the pre-experimental dressing had been applied very irregularly and neither the pH nor the amount of disease bore any relation to the dressing of lime made in 1933. The Bangor and Pwllheli trials were therefore not comparable as regards amounts of lime applied, but comparisons between plots from the point of the pH reaction of the soil and its relation to disease control were not affected.

Results of Trials 1933-35.

(i) *Changes in pH of Soil.*

It will be seen from Table II that the pH of the soil at Pwllheli showed a well marked fluctuation between early summer and winter, being higher each winter than in the intervening summer months. The greatest rise in pH, following any particular dressing of lime, occurred in the first year and thereafter it rose only slightly, but after three years there was no evidence of the effect of lime falling off.

TABLE II.

Changes in pH of Soil at Pwllheli from 1933 to 1935.

	Two Tons Lime applied 1932.					*No Lime applied in 1932.*				
Lime (Tons per Acre) in 1933.	*pH 1933. May*	*pH 1933. Nov.*	*pH 1934. April.*	*pH 1934. Dec.*	*pH 1935. May.*	*pH 1933. May*	*pH 1933. Nov.*	*pH 1934. April.*	*pH 1934. Dec.*	*pH 1935. May.*
0	5.76	6.59	6.55	6.55	5.80	5.25	5.58	5.61	5.69	5.28
2	,,	6.70	6.62	7.11	6.79	,,	5.90	6.02	6.78	6.82
4	,,	7.53	6.87	7.33	6.42	,,	6.86	6.64	7.22	7.04
6	,,	7.35	7.21	7.57	7.14	,,	7.08	7.09	7.70	7.12
8	,,	7.59	6.92	7.76	6.88	,,	7.08	6.72	7.54	7.84
10	,,	6.82	6.99	7.78	7.06	,,	7.17	6.61	7.61	7.42

No such seasonal effect was to be seen at *Bangor* owing to the high buffer action of the soil. The land was approaching saturation with CaO as appears from the fact that the pH showed relatively little change during the three years after heavy dressings of lime; ten tons being required to raise the pH from 7.52 in 1933 to 7.99 in 1935. The average rise in pH due to various dressings of lime at *Pwllheli* is given in Table III.

TABLE III.

Changes in pH of Pwllheli Soil due to Lime

Lime (Tons per Acre).	*Mean Rise in pH after Three Years (Initial pH = 5.25)*
2	1.07
4	1.79
6	1.87
8	2.09
10	2.17

In view of Chupp's statement that infection occurred when the pH was less than 7.2 to 7.4, it is of interest to note that an application of six tons of lime per acre was required at Pwllheli

to raise the pH to 7.22 in winter, but even this became barely 7.0 in summer. When eight tons were applied the pH varied from 7.54 in winter to 7.34 in summer.

(ii) and (iii) *Direct v. Indirect Action of Lime.*

For the reasons already given it was not possible to make a direct comparison between the control effected at Bangor and Pwllheli respectively, but useful data were nevertheless obtained at both centres. At *Bangor* both exchangeable CaO and pH of the soil were much above that believed to be necessary to prevent infection, yet 37 per cent. of cabbages were badly clubbed under conditions of saturation with exchangeable CaO (0.41 per cent.) and a pH = 7.81. It may be that differences of 15 to 20 per cent. infection which occurred in plots with the same pH can be used as demonstrating irregular contamination with the organism rather than as indicating any absence of relation between pH and infection, although the usual heavy attack at Bangor gives more weight to the second possibility. It is true also that on the average the more alkaline soils showed less disease than did the acid ones, but even so cauliflowers growing in soil with a pH = 7.85 gave 71.4 per cent. infection as compared with 85.3 per cent. in plots with a pH of only 5.68. It would seem that such results would have been impossible if a decided alkalinity of the soil inhibited infection. Similarly at Pwllheli, heavy percentages of badly clubbed plants, varying from 100 per cent. in the case of cauliflowers to 90 per cent. with brussel sprouts and 60 per cent. with cabbages occurred in plots in which the pH = 7.45 at the planting time and 7.77 at the end of the growing season and the conclusion must be reached, as at Bangor, that a high pH of the soil does not, in itself, prevent infection with finger and toe disease.

(iv) *Comparison of the Residual effect of a Small Application of Lime with the immediate effect of Larger Dressings.*

During 1933 the only difference between the two trials at Pwllheli was the fact that one had received a uniform dressing of two tons of ground lime on all thirteen plots in the previous year; these plots are referred to below as " residual lime " plots. A comparison of disease on otherwise comparable plots in the two trials would therefore show the effect, if any, of this basic two ton dressing. Similarly other comparisons would be possible to ascertain what dressing was required in 1933 to give an immediate effect equivalent to the residual effect of the small 1932 application. In the summary of results which follows,

these comparisons are made separately for cauliflowers, cabbages and brussels sprouts in respect of total disease found and the proportion of plants so badly attacked as to be unsaleable.

As regards total disease, 100 per cent. was recorded on all "control" plots (*i.e.* 0 + 0; 2 + 0 tons lime) with all the different brassicae grown. Nor was any improvement effected in the case of cauliflowers with any dressing of lime up to and including 2 + 10 tons. Brussels sprouts showed a progressive increase in control until this reached 30 per cent. (70 per cent. disease) with the heaviest dressings irrespective of whether the plots had received the two tons of lime in 1932. With cabbages, however, the four-ton plots with residual lime (2 + 4 tons) showed a slight (5 per cent.) control as against no control without residual lime; and the six-ton plus residual lime plots gave 30 per cent. control as compared with 12 per cent. without residual lime. This apparent effect of the 1932 dressing was, however, lost with the heaviest dressings of ten tons, the same control (45 per cent.) being found with and without residual lime.

Similar differences were found in the reactions of the various crops in the proportion of plants badly attacked. Cauliflowers, even on the residual lime plots, showed every root badly clubbed until 2 + 10 ton dressings were reached when 28 per cent. fell into the slightly attacked group. With brussels sprouts it is interesting to note that although the heaviest dressings on the non-residual lime plots failed to reduce the intensity of the disease there was a rapid improvement on the residual lime plots; 50 per cent. of the roots being badly attacked on the 2 + 2 ton plots and only 10 per cent. on the 2 + 10 ton plots. Cabbages showed little reduction in the number of badly attacked roots on the non-residual lime plots until a six-ton dressing was reached, when the number was reduced to 78 per cent.; this becoming 45 per cent. with a ten-ton dressing. On the residual lime plots 2 + 4 tons reduced the badly attacked plants to 70 per cent., 2 + 6 tons gave 55 per cent. but, once again, with the heaviest dressings of 2 + 10 tons the reduction in badly diseased plants to 45 per cent. was no greater than in the comparable non-residual lime plots.

Three points emerge from these results. (*a*) Where any control was effected either in number of plants infected or in the intensity of attack it showed a progressive improvement with increasing amounts of lime applied, in contra-distinction with the lack of any clear relation to be found between control and pH reaction of the soil. (*b*) Although a two-ton dressing of lime was ineffective either immediately or after a period of twelve

months, this residual effect plus the immediate action of heavier dressings was quite marked until the heaviest dressings were reached, when it was lost. (*c*) It is suggested that the explanation lies in the action of lime being a directly lethal one on the spores, and the success obtained is therefore dependent on the degree of incorporation of the lime into the soil. The immediate effect of very heavy, and unecomonic dressings of lime will, of course, equal that only to be obtained with small dressings after a period of time. It appears to the writer, however, that emphasis has been laid upon this time factor alone and that the saving in lime made possible by more thorough tillage has not received the attention it deserves.

It was to be expected that as more lime became incorporated in the soil year by year there would be a corresponding increase in control of finger and toe. Some improvement was indeed effected as regards the number of plants falling in the badly infected group, but in general the control was not markedly increased in the second and third years. The writer has no doubt that this was due to the very high initial contamination of the soil, and still more to the continued growing of brassicae without rotation, with the result that vast quantities of viable spores were returned to the soil each year. Quite similar results were obtained at Craibstone in the trials already mentioned.

(v) *Susceptibility of the Different Brassicae under Experiment.*

The almost complete failure to reduce disease in cauliflowers either in intensity or in number of plants attacked, with the heaviest dressings of lime, is sufficient proof that the soil even then contained an ample supply of viable spores. It follows that the comparative success obtained with brussels sprouts and cabbages (and, it may be noted, the almost complete eradication of disease in swedes at Bangor) must be due to the reaction of the plants to infection : *i.e.* to the varying susceptibility shown by the brassicae under trial. In Table IV the various brassicae have been grouped in order of decreasing liability to contract finger and toe disease. As the object is to guide the practical grower, the standard adopted is the percentage of seriously infected plants rather than the total number showing slight signs of infection. What is believed from general observation to be the relative susceptibility of other cruciferous crops is also indicated in the Table.

The actual percentages of disease occurring in susceptible varieties of swede at *Bangor* (varying from 2 per cent. to 9 per cent. in all cases except three which gave 16, 20, and 29 per cent.

respectively) are not quoted in Table IV owing to the unknown amount of lime applied before the trials were begun. A new and important question, however, is raised by this low incidence

TABLE IV.

Cruciferous Crops arranged in order of Decreasing Susceptibility.

Crop.	*Unlimed Control. % Infect.*	*8 Tons CaO % Infect.*	*10 Tons CaO % Infect.*
Cauliflowers	100	100	77
Spring-sown cabbage	100	85	70
Savoy cabbage	100	80	54
Brussel sprouts	100	55	50
Suscept. swede varieties	—	—	—
Resistant swede varieties	—	—	—
Yellow turnip	—	—	—
Marrow-stemmed kale	—	—	—

in swedes which occurred in plots showing heavy infection with other brassicae. If the differences found (*e.g.* between swede and cauliflower) are completely explainable on the basis of differing susceptibiity, what is the explanation of extremely heavy attacks on *swedes* under farm conditions? It is difficult to believe that land could be more heavily contaminated than the market gardens used in these trials, yet the writer recalls one farm on which finger and toe was so severe on swede that the entire crop from one and a half acres was carried on one barrow load! It is conceivable that cauliflowers suffered more severely than swedes in these market gardens largely because the disease had been passed through many generations of cauliflowers and allied brassicae, and that a similar explanation would account for heavy swede losses on farms. In any case it suggests that the possibility of the existence of different physiological strains of the disease needs thorough investigation. Certain observations made by the writer in the Conway Valley in 1920 suggested this hypothesis, and the question was also raised in 1985 in a letter to the present writer from Dr. J. C. Walker of Wisconsin, U.S.A., as a possible explanation of the results of his own trials. In view of the results obtained in the present work, and the fact that the hypothesis might offer an explanation of the very different degrees of susceptibility shown by the same variety of swede in different areas, it would seem that the possibility of the existence of physiological strains of the disease cannot be ignored in any future work.

(vi) *Minimum Dressings of Lime Required for Different Brassicae.*

The conditions of extremely heavy contamination of the land under which the trials were carried out, together with the continuous growing of brassicae without rotation were, of course, not typical of ordinary farms or market gardens. It was not to be expected therefore that any conclusions could be arrived at as to the minimum dressing of lime required to secure adequate control of finger and toe, and indeed, with the exception of swedes, control was not obtained even with the heaviest, uneconomic, application. Apart from this, the trials only indicate that an amount of lime sufficient, under ordinary commercial conditions, for crops shown in the lower half of Table IV would be inadequate for those in the upper half.

Acknowledgments.

The writer wishes to express his gratitude to the Authorities of St. David's Hospital, Bangor, and to Mr. W. D. Jones of Brynhynog, Pwllheli, for the use and necessary cultivation of the land used in these trials; and to the Management of Limestone Products, Ltd., St. George, Abergele, for the supply of lime free of cost. Acknowledgment is also gladly made of the help given throughout the work by the Laboratory Assistant, Mr. G. L. Turner.

Summary.

(1). An account is given of trials carried out over three years in soils very badly contaminated with finger and toe, and in sharp contrast as regards texture, percentage of exchangeable CaO, and pH index.

(2). The rate of change of soil pH with different applications of lime, and the occurrence of seasonal fluctuation in pH value are recorded.

(3). Little direct relation can be traced between pH reaction and degree of control effected, whereas there is a clear association between amount of lime applied and control.

(4). The action of lime is believed to be a direct lethal one on the spores, and any residual effect found with small dressings is attributed to cultivation assisting in the proper incorporation of the lime in the soil.

(5). An attempt is made to indicate the relative susceptibility of different cruciferous crops to finger and toe.

(6). The possibility of the existence of different physiological strains of the disease is suggested.

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GALL MIDGES AFFECTING GRASS SEED PRODUCTION IN MID-WALES.

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Foreword.

The gall midges (*Cecidomyidae*) are small, delicate, two-winged flies allied to the gnats, march-flies and crane-flies. They include a large number of important pests of agricultural and horticultural plants, of which the clover, pear, swede and pea midges may be mentioned as being of local interest.

The gall midges of grasses may be conveniently divided into two categories, according as to whether they attack the reproductive or the vegetative parts of the plants. Those belonging to the latter category, although by no means unimportant, are, on the whole, much less injurious than those belonging to the former. It is with the midges attacking the flower and seeds of grasses that the present paper is concerned.

The gall midges of this category include a number of species, of which a large proportion belong to the genera *Contarinia* and *Dasyneura*. They first received serious study in Finland, where Reuter (1895 and 1900) investigated two species of midge on

meadow foxtail grass. These and other midges have since been recorded and studied in various European countries, particularly in Denmark, Germany and England. Barnes, at Rothamstead Experimental Station, has made a number of important contributions to the subject and has also published a useful list of all species recorded up to 1931.

One of the foxtail midges, *viz.*, *Dasyneura alopecuri* (Reut.), was introduced into New Zealand about 1910, in seed imported from Europe, and rapidly became a serious pest. Two of these midges have also, recently (1935), been recorded in Canada, where they were previously unknown.

Life-cycles.

The life-cycle is, on the whole, much the same in all species of gall midges attacking the reproductive parts of grasses. There is generally only one brood in the year; the adults emerge, as a rule, in April, May or June (according to the species), and the fertilised females lay their eggs on the heads of the grasses. The larvae hatch out after a short time, and may be observed on the grass heads, in most cases, until the middle or end of July; in some grasses, *e.g.*, meadow foxtail, but not in all, the presence of the larvae within the so-called " seeds " can be readily detected by the red colour imparted to the latter.

The larvae of some species (*e.g.*, those of *Contarinia*) feed upon the ovary before the seed is formed, and, when full-grown, " jump " to the soil. Those of certain other species (*e.g.*, *Dasyneura alopecuri* (Reut.), and *Stenodiplosis geniculati* (Reut.), however, feed upon the developing seed, which is ultimately destroyed, and eventually come to lie within the otherwise empty " seed-coat." The larvae of this latter type do not migrate to the soil, and consequently the florets containing these are found among the good seeds when the crop is harvested; they are able to continue their development as soon as the seeds are sown.

The larvae of both types pupate in the soil, within or without the seed coat as the case may be, in spring, and the adults emerge later to recommence the life-cycle.

Stenodiplosis geniculati, in England, has two broods in the year, the adults of the second brood emerging mainly in July. *Dasyneura alopecuri* is single-brooded in Britain but appears to be double or multi-brooded in New Zealand.

Notes on the Species Recorded in Mid-Wales.

The following notes are selected from the results of an extensive survey of the gall midges of grasses in Mid-Wales

(Cardiganshire and Montgomeryshire). Some of the species have not yet been identified and others have not been previously described. Some two or three species of predatory midge larvae were observed during the survey, and are included here for the sake of completeness.

Host-Plant Index.

Host.	*Gall Midges.*
Meadow foxtail. *Alopecurus pratensis* L.	*Contarinia merceri* Barnes. *Dasyneura alopecuri* (Reut.). *Stenodiplosis geniculati* (Reut.).
Tall oat grass. *Arrhenatherum avenaceum* Beauv.	*Contarinia arrhenatheri* Kieff. *Arthrocnodax* sp. Two unidentified species.
Cocksfoot. *Dactylis glomerata* L.	*Contarinia dactylidis* (H. Lw.). *Dasyneura dactylidis* Met. *Lestodiplosis* sp. One unidentified species.
Red fescue. *Festuca rubra* L.	*Contarinia* sp.
Yorkshire fog. *Holcus lanatus* L.	*Contarinia* sp. *Lestodiplosis* sp. One unidentified species.
Perennial rye. *Lolium perenne* L.	*Contarinia lolii* Met. *Lestodiplosis* sp. One unidentified species.

Meadow Foxtail Grass—Alopecurus pratensis L.

The three species recorded on this host-grass are among the best known gall midges of grasses. In Mid-Wales, *Contarinia merceri* is widely distributed and is generally much more abundant than either *Dasyneura alopecuri* or *Stenodiplosis geniculati*. The adults of this species were on the wing during the whole of June, 1935, and the larvae were present in the grass heads until the latter half of July. A 50 per cent. infestation was recorded on several old seed plots; only one set of samples —from an isolated, first-year crop at Ponterwyd, Cardiganshire —proved to be entirely free from this midge.

The other two species are much less injurious and only one of them, *viz.*, *D. alopecuri*, is present in Cardiganshire. In Montgomeryshire, in 1935, *S. geniculati* infested 12-15 per cent. of the foxtail seeds and *D. alopecuri* was responsible for blindness in a further 5 per cent. or so.

Tall Oat Grass—Arrhenatherum avenaceum Beauv.

This grass is normally found in hedgerows and is of little agricultural importance. The midges infesting its florets and seeds, however, are worthy of mention if only because of the

possibility of economic grasses being used as occasional hosts.

The larvae of one species, *viz.*, *Contarinia arrhenatheri*, are relatively abundant in Montgomeryshire, where about 10-25 per cent. of the tall oat grass seed is infested, but they appear to be almost completely absent from Cardiganshire.

The predatory larvae, which apparently belong to a species of *Arthrocnodax* Rübs., were observed only in Montgomeryshire and Shropshire, in which two counties they were very abundant.

Two other species of midge larvae were recovered from tall oat grass seeds; one of them is phytophagous, but the feeding habits of the other are unknown.

Cocksfoot grass—Dactylis glomerata L.

The cocksfoot midges, *Contarinia dactylidis* and *Dasyneura dactylidis*, are widely distributed in Mid-Wales, but the latter species is not very abundant in Cardiganshire. From a study of the distribution of the two species it would appear that the latter can exist at slightly higher altitudes than the former. As a rule, the combined infestation is never very high, although, on one heavily infested plot at Aberystwyth in 1935, at least 36 per cent. of the seed crop was destroyed.

A third species of midge attacking cocksfoot was also observed. It was present in samples of seeds from a number of different localities, but was not sufficiently abundant to be ranked as a significant pest.

Red fescue—Festuca rubra L.

A number of orange-red larvae of the *Contarinia* type were obtained from samples of fescue collected at the Plant Breeding Station, Aberystwyth, on June 29th, and again on July 6th, the infestation on these two dates being 12 per cent. and 4 per cent. respectively. By July 11th the larvae had all descended to the soil.

In colour, dimensions, and shape of the sternal spatula, the larvae closely resemble those of *Contarinia dactylidis* on cocksfoot, but since, however, the larvae of all species of *Contarinia* are very similar in structure, too much importance must not be attached to this resemblance. According to Metcalfe, who worked at Rothamsted Experimental Station in 1932, *Festuca rubra* var. *arenaria* is immune to attack by *C. dactylidis*. It would appear, therefore, that the midge on fescue is specifically distinct from that on cocksfoot—a conclusion which is supported by the observations recorded above, *viz.*, that the fescue larvae had dropped to the soil before July 11th, whereas on July 19th,

there was still a considerable number of larvae in the cocksfoot seeds.

Barnes has previously recorded the occurrence of gall midge larvae on fescue, but comparison of his collection with that of the present writer, has shown that two different species are involved. The second species has not been observed at Aberystwyth.

Yorkshire fog grass—Holcus lanatus L.

The seeds of Yorkshire fog grass were found to be infested with the larvae of two species of gall midge. One species is again referable to the genus *Contarinia;* the other has not been identified. During the course of the investigation it became apparent that the larvae of the former were widely distributed throughout Montgomeryshire but extremely rare in Cardiganshire. Those of the latter species were recorded only from Montgomeryshire (and Shropshire) and then only in relatively small numbers.

The larvae of *Lestodiplosis* sp., which were also found on Yorkshire fog grass, are predatory, but it is not known whether they prey upon the other gall-midge larvae or on the numerous other insects which occur on this grass.

Perennial rye-grass—Lolium perenne L.

Contarinia lolii is the only economically important gall midge attacking perennial rye-grass. According to observations made in Montgomeryshire in 1935, the larvae of this species attain their maximum abundance in the seeds about June 20th—25th, and the vast majority of them have migrated to the soil by July 7th. This phase of the life-cycle is, therefore, earlier than in most species of *Contarinia* on grasses. The highest infestation recorded was about 5 per cent., so that, on the whole, this species is much less injurious than some of those mentioned above.

A few larvae of *Lestodiplosis* sp. and of an unknown species were also observed.

General Remarks.

As may be gathered from the foregoing account, five agricultural grasses, *viz.*, meadow foxtail, cocksfoot, red fescue, Yorkshire fog and perennial rye, are subject to injury by gall midges in Mid-Wales. Of these midges, nine species may be ranked as pests, of which three occur on foxtail, three on cocksfoot, and one on red fescue, Yorkshire fog and perennial rye respectively. Their importance is roughly in the order given. Other species also occur on these grasses but are either not

numerous enough to be regarded as pests or are predatory, and therefore, to some extent, beneficial.

In assessing the economic importance of these gall midges, it is assumed that the loss to the hay crop is almost negligible. The effect on the seed production, however, is evidently serious, especially on foxtail, in which from 20-60 per cent. of the crop may be destroyed. On the other grasses the loss is only relatively less important. In foxtail, moreover, the injury is two-fold; in the first place, the larvae of *Contarinia merceri* give rise to a considerable amount of light seed, thus causing a serious diminution in the weight of the crop; and in the second place, even after the threshing and cleansing operations, a certain proportion of the seed still contains larvae of *D. alopecuri* and *S. geniculati* and so the "real value" of the graded seed is adversely affected.

Since the investigation was commenced in 1934, it has been established that the gall-midges of grasses are definitely more abundant, both in species and in numbers, in Montgomeryshire than in Cardiganshire. The cause of this uneven distribution is probably to be found in the markedly different weather conditions obtaining in the two counties. Its unfortunate significance for the seed-producing areas in Montgomeryshire (and Shropshire) will be readily appreciated.

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THE CONTROL OF GALL MIDGES AFFECTING SEED PRODUCTION IN GRASSES.

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Introduction.

The severity of the damage caused by gall midges to the seed of various cultivated grasses was not fully realised by seed growers in the British Isles until Barnes (1930 (1) published the results of his investigations into the life histories and control of the three species attacking meadow foxtail. Even then, perhaps, it was not known to more than a few growers that meadow foxtail, although probably the most heavily attacked grass in this country, was by no means the only one to suffer from the depredations of midges. More recent work (Metcalfe) (4) in 1933, has revealed the presence of two species of gall midge on cocksfoot, and one on Italian rye-grass; and the observations of the present writers in Mid-Wales and West Shropshire have revealed the occurrence of gall midges on red fescue, tall oat grass, and Yorkshire fog, in addition to the grasses mentioned above. Consideration of these and other records leads to the conclusion that almost all of the important agricultural grasses are susceptible to attack by gall midges. Whether all the midges, particularly those belonging to the genus *Contarinia*, recorded on the different grasses are in reality specifically distinct, has not been definitely established. This question is of utmost importance to seed growers who, for obvious reasons, desire to know whether a midge pest of one species of grass will spread to another.

The seed grower who wishes to ascertain the extent to which his grasses are infested by midges should examine the grass heads on a still evening in June or, preferably, on several such evenings in May and June. During this period the minute, red or yellow gnat-like females of whichever species are present, will be found crawling over the florets and laying their eggs. The latter are not visible to the naked eye, but later on, the maggots which hatch out from them grow in size and soon become conspicuous by virtue of their bright red, orange, or yellow colour. These can sometimes be seen through the palea and glumes, as in the case of those infesting the seeds of foxtail, but very often, however, it is necessary to dissect the seeds before finding the

maggots, or to moisten them and put them aside for a few days, in the course of which the full grown maggots will, in most cases, emerge of their own accord. Since the maggots of most species drop to the ground before or during July, the examination must not be delayed after the end of June or beginning of July, otherwise the midge infestation will be indicated only by blindness among the florets. In some species (*Dasyneura alopecuri* (Reut.) and *Stenodiplosis geniculati* (Reut.) on foxtail), however, the maggots remain within the otherwise empty " seed-coat ", and a certain proportion of them accompany the viable seed through the harvesting, threshing, and cleansing operations, until it reaches the final purchaser.

The degree of infestation varies considerably among different grasses, and even in the same grass species grown in different localities or under different cultural conditions. For instance, the percentage infestation by *Contarinia merceri* Barnes, of a third crop of meadow foxtail seed at Aberystwyth, was 60 per cent. in 1935, while the infestation of an adjacent island of perennial rye-grass by *Contarinia lolii* Metcalfe (also a third seed crop and grown under similar conditions), was considerably lower than 1 per cent. Other records of infestation of meadow foxtail seed varied from 0 per cent. to 50 per cent. A cocksfoot stand appears to be relatively free from midge larvae for the first two or three seed crops, but an old stand, under conditions conducive to the multiplication of midges, may become heavily infested. Infestations up to 10 per cent. and 12 per cent. have been observed on Yorkshire fog and red fescue, respectively, but timothy and agrostis do not appear to be attacked in Mid-Wales and Shropshire, although gall midge larvae have been observed on them in other localities.

There is abundant evidence that, under certain conditions, midges may have a devastating effect on grass seed crops. In New Zealand, for instance, prior to 1915, excellent crops of meadow foxtail, germinating between 70 per cent. and 80 per cent., were produced, but after the accidental introduction of *Dasyneura alopecuri* (Reut.) about the year 1910, the midge pest became so bad in a few years that the germination fell to about 10 per cent., thus precluding the possibility of foxtail seed production in New Zealand until such time as the midge can be satisfactorily controlled.

Recent correspondence with investigators in the British Dominions has elicited the following information concerning the foxtail midges : in New Zealand, as stated above, the accidental introduction of one of the midge pests has ruined the industry;

in Australia, a preliminary examination of foxtail seed failed to reveal the presence of midges; in Tasmania, where no foxtail is grown for seed, it is reported that none of the midges has been observed; in South Africa, no direct observations have as yet been made; and, finally, in Canada, recent investigations have shown that at least two species, *viz.*, *Dasyneura alopecuri* (Reuter) and *Stenodiplosis geniculati* (Reuter), have been introduced, and that there is every likelihood of the third species, *Contarinia merceri* Barnes, being present.

Although, until recently, relatively little attention has been devoted to the study of control measures for midges affecting seed production in grasses, the danger of loss to seed growers as the result of the activities of these pests is of sufficient magnitude to justify a review of the subject and the suggestion of a few practical lines of control.

Natural Limitations.

Comparatively little attention has been paid to the manner in which the complex of environmental conditions produces a limitation in the number of these midget pests. Barnes (1933) (3) has studied the problems of fluctuations in populations in *Dasyneura alopecuri* (Reut.) on foxtail, and in the wheat midges *Contarinia tritici* (Kirby) and *Sitodiplosis mosellana* (Géhin) and the same author (1930) (2) has attempted to evaluate the factors governing the emergence of various gall midges. The conclusion which he draws is that the fluctuations can be largely attributed to changes in weather conditions.

The observations of the present authors suggest that wind velocity and precipitation have an important effect in limiting the numbers and distribution of these midges. The females ascend to the heads for the purpose of ovipositing only during still weather and in the absence of rain. It would appear probable, therefore, that the weather conditions obtaining during the flight period of the midges would have an important effect on the intensity of the subsequent infestation. A striking difference between the prevalence of gall midges of grasses in Cardiganshire and Montgomeryshire (the midges are more abundant both in species and numbers in the latter county), can probably be attributed to different climatic conditions, although this has not yet been definitely established.

The introduction of *Dasyneura alopecuri* into New Zealand, and its subsequent rapid multiplication, indicates the important part played by biotic and climatic factors in the control of the pest in European countries where it is definitely less injurious.

Whether greater stress is to be laid on the absence of the parasites than on the climatic differences is a moot point, but that the latter are by no means unimportant, is indicated by the fact that in New Zealand the species is double- or multi-brooded, whereas in England and, presumably, in other European countries, it is typically single-brooded with, at most, only a partial second brood emergence.

Among the recorded predators of gall midges of grasses are various robber-flies, especially Empidae (Tomaszewski 1931 (8) Barnes 1930 (1)), larvae of *Lestodiplosis* spp. Barnes, 1930 (1) and spiders (Tomaszewski, 1931 (8), confirmed by the observations of the present writers). Numerous parasites have been recorded and include, in particular, flies of the Hymenopterous families Chalcididae and Platygasteridae. There appears to be no record of these beneficial insects having been employed against the midge pests.

Seed Treatment.

Certain species of gall midge, *e.g.*, *Dasyneura alopecuri* and *Stenodiplosis geniculati* on meadow foxtail, can be partly controlled by treating the seed. The larvae of these species, instead of migrating to the soil when full grown, remain within the "seed-coat" and are harvested with the good seed. The usual routine processes such as threshing and cleaning remove only a relatively small percentage of the infested "seeds" so that, consequently, an additional method of purification must be employed.

Seed kept over for one year is very nearly midge-free, since the majority of the flies tends to emerge in the first year. Barnes (1) has shown, however, that some emergences occur in the second year. For districts, therefore, where the midges have already been established, kept-over seed should be perfectly satisfactory. But for export to areas where the midges have not yet appeared more drastic methods of obtaining midge-free seed must be employed.

Rostrop (1919) (7) at the State Seed Testing Department, Denmark, has tried out several methods of killing the larvae. The important results of her investigations are embodied in the following recommendations :—

(*a*) Heating the seed to a temperature of 59°-60° C. for thirty-five minutes.

(*b*) Treatment with carbon di-sulphide (1 gm. per litre of air), so far as possible in a sealed room.

Either of the methods may be employed. The destruction of the larvae is said to be complete and the germination of the seed

is in no way impaired. These methods of seed treatment can obviously be carried out only in properly equipped stations and are practicable only when large quantities of infested seed have to be handled.

Field Measures.

Historical.

Control measures which can be employed in the field are, of course, the only ones applicable against such species as *Contarinia merceri* Barnes, on foxtail, and *C. dactylidis* (H. Lw.), on cocksfoot, the larvae of which migrate to the soil at the end of their feeding period, and are consequently not found in the seeds when harvested.

Various kinds of traps have been tried from time to time, but without much success. The efficacy of a light trap is dependent upon weather and lunar conditions to such an extent as to render the trap somewhat unreliable as a method of control. Barnes (1) suggests the use of bonfires, a method which has been recommended for the control of wheat midges. There appears to be no record of the use of baits for the purpose of trapping gall midges of grasses, although this method certainly merits a trial. It is evident that light or chemical traps would give significant results only during the period when the abundance of the midges is at its maximum.

A mechanical trap consisting of a sack smeared with molasses and drawn over infested plots at the time when the female midges are ovipositing has met with little success in Germany. Spraying cannot be regarded as a practical proposition, and soil fumigation with various chemicals, also tested in Germany, has proved inefficacious.

Some Practical Suggestions.

Seed growers who have grasped the importance of phases in midge life history, and in particular the periods at which the midges are most vulnerable, are in a position to organise their cropping so as to reduce the midge population affecting the seed crops to a minimum. The spatial isolation (a minimum of 400 yards recommended), as a safeguard against pollen contamination for " islands " of pedigree grasses grown for seed, provides also a measure of protection against midge migration from a possibly affected crop, and in view of the possibility of midges passing from an old to a new island of a particular strain of grass when they are grown contiguously, every effort should be made to

isolate islands of different ages even when the same strain of grass is concerned.

A rational means of checking insect pests is afforded by the sowing of a pasture type of rye-grass with wild white clover, and taking seed crops of rye-grass and white clover in alternate years. When white clover seed is to be taken, the sward is grazed hard and frequently until mid-June. This very largely suppresses the rye-grass inflorescences, and consequently the midges are unable to multiply to any great extent. It should be noted that pasture strains of grasses produce fewer flowering stems in the aftermath, or after they have been grazed hard in spring, than commercial strains. Incidentally, it may be mentioned that in the years when rye-grass seed is taken, the insect pests of the clover tend to be reduced by harvesting in mid-July, and close grazing the aftermath.

Apart from the rye-grasses, the wide drill system is recommended for grass seed production. Very thorough inter-drill cultivation periodically throughout spring, summer, and autumn, should tend to keep the midge population down. If observations show that the numbers of midges are beginning to assume dangerous proportions, the grass rows should be grazed hard during the following year, or several cuts of short grass should be taken for artificial drying. The grazing or frequent cutting of a cocksfoot crop is preferable to the taking of a hay crop for the control of midges.

Seed growers who adopt the modern practice of harvesting all the hay in June as far as weather conditions permit, and keep inflorescences on the pastures under control by means of the mowing machine are, by so doing, assisting to suppress the midge pest. The aftermath of short leys should always be grazed bare in preference to taking a second hay crop in the same year, again for the purpose of controlling the flower heads of grasses.

Barnes suggests cutting back meadow foxtail in spring, in order to delay the flowering period until the peak of the midge egg-laying period has passed. By this method the numbers of midge larvae can undoubtedly be reduced appreciably, but unfortunately for the seed grower, the data collected at Aberystwyth show that cutting back in late spring may cause a definite reduction in the amount of viable seed produced.

Neither is cutting back likely to be a valuable method of controlling midges which attack the leafy cocksfoots and creeping red fescue, for when they are defoliated in spring they tend to produce very disappointing seed crops later on.

In choosing land for the production of seed from grasses susceptible to midge attacks, low lying fields and excessively

sheltered situations should be avoided wherever possible, for they are more apt to breed midges than exposed slopes and open spaces. The female midges lay their eggs only in still weather, and a situation where a breeze normally blows is more likely to produce midge-free crops than one where there is consistent calm. There is also less danger to the grass from frost when it is grown on hill slopes.

Districts which are almost wholly arable, and have large fields under the plough, are suggested as areas for the cultivation for seed of those species of grass, such as meadow foxtail, which are highly susceptible to midge damage. A district should be chosen where foxtail is absent, or practically absent, from neighbouring leys or old pastures, and care should be taken that no seed is introduced that has not been certified free from midge.

Finally, if it is ultimately proved that one grass species cannot be infested to any serious extent by the midge or midges which attack other grass species, the seed grower could largely overcome the pests by changing the species of grass grown for seed every few years.

Summary.

The majority, if not all of the important agricultural grasses, are liable to attack by gall midges possessing flowerhead feeding larvae, with consequent drop in seed yield. It is probable, although not fully established in all cases, that each species of midge is specific to its own grass species, and will not attack any other species. Various more or less unsuccessful attempts have been made in the past to control these midges. The midges may be divided into two groups, in the first group, the larvae remain in the seed until the following season. Spread of these pests into districts hitherto free can be avoided by the use of midge free seed which can be obtained by the adoption of suitable measures. In the second group the larvae, after they have finished feeding, leave the seed and drop to the ground. The partial control of these, and of members of the first group, can be obtained by the adoption of appropriate methods of cultivation as described above.

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THE GAPEWORM PROBLEM.

By T. I. Davies, M.Sc.,
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1. Introductory.

Recent investigations into the biology of the gapeworm have indeed been exceptionally fruitful, and it is thought that an account of these researches will prove both interesting and helpful to the numerous poultry breeders who form an increasingly important section of the agricultural populace in Wales. The importance of this disease is expressed not only in high mortality in young chickens, but also in the loss in weight and general set-back in the individuals less seriously affected.

The disease is extremely prevalent, and its sudden outbreak on farms hitherto unaffected has always been its most puzzling feature. This suddenness of attack has drawn the attention of many scientific workers, and recent researches have mainly been directed towards discovering the methods by which the parasites are spread.

2. Turkeys and Wild Birds in the Distribution of "Gape."

Dr. Ransom, in 1920, stressed the importance of the turkey in the dissemination of "gape" in America. In 1917 and 1920 he found that 28.6 per cent. and 22.5 per cent. respectively of the turkeys examined by him harboured "gapes," the parasite being carried by the adult birds without apparent discomfort.

It is evident therefore that the eggs of gapeworm coughed up by infected turkeys, or passed out with their droppings, will contaminate the ground on which the birds are kept. These eggs will develop into infective larvae within one week of their liberation from the host. As will be shown later, the gapeworm of the turkey will develop in chickens, and obviously therefore, turkeys are exceedingly dangerous sources of infection when kept on the same ground as young chicks during the first six weeks of the latter's life. Dr. Ransom concluded that the turkey is apparently the most important agent, not only in spreading the disease, but also in enabling the parasite to "bridge" the autumn and winter, when no chicks are being reared. He indeed went as far as to express the view that the abolition of turkeys would mean the disappearance of "gapes" from chickens.

The suddenness of attack, which has so often surprised the unfortunate breeder, however, still remained a mystery, until

Dr. E. A. Lewis, then working at the University College of Wales, Aberystwyth, discovered that various wild birds—particularly the starling—act as important reservoirs of "gape." In the winter of 1925-6 he examined the windpipes of 482 starlings, and found that 30 per cent. contained *Syngamus trachea*, the gape-organism. His data (1926) also show that there is a definite increase in the percentage of infection towards spring, when young chickens are due to hatch. In his opinion these results disclose "that starlings, at least, are as important a factor as, if not a more important, and much more efficient a distributor of the gapeworm than is the turkey." Dr. Lewis cites an instance of an estate near Aberystwyth on which a plague of starlings in the winter of 1924-5 was followed by a high mortality among young pheasants due to "gape" in the summer of 1925.

In view of the migratory habits of the starling it is evident then, that here we have an explanation of the suddenness of attack that is so characteristic of the disease.

3. The Role of the Earthworm.

Walker (1886) conducted experiments to determine the part played by the various soil-inhabitants in the transmission of "gape." He took earthworms, slugs and wood-lice from the vicinity of infected coops and fed them to young chickens. Those fed on earthworms contracted "gape," and he therefore concluded that earthworms play an important role in the transmission of the disease. He found that the eggs of Syngamus, when ingested by the earthworm, develop into infective larvae inside the gut. Such infected earthworms are dangerous sources of infection, and in their migration within the soil they act as a means of contaminating fresh areas in the close vicinity. The movements of earthworms are admittedly limited, but they ensure thorough contamination of the area concerned, and bring about a gradual extension of this area in a manner that intensifies the effect of the more potent but erratic distributors, the wild birds.

The more recent work of Drs. D. O. Morgan and P. A. Clapham at the Institute of Agricultural Parasitology has further brought the role of the earthworm into an interesting new light. These authors (1934) have shown that whereas it is difficult to transmit *Syngamus trachea* direct from various wild and domestic birds to chickens, the same transference is easily effected if the earthworm is employed as intermediate host. Thus if earthworms of the species *Eisenia foetida* that have

previously been fed with the eggs of gapeworm from the starling are fed to young chickens, the latter will suffer a 100 per cent. infection.

Thanks to Dr. Clapham it is also known that the species of earthworm vary in importance, inasmuch that the smaller *Eisinia foetida* affects 100 per cent. infection whilst the larger *Lumbricus terrestris* only brings about infection in about 50 per cent. of cases. *Eisenia foetida* is the small reddish earthworm so often found in manure-heaps, among dead leaves and in various other places where there is an abundance of decaying organic matter. It is therefore abundant on chicken runs that are allowed to become contaminated with the birds' droppings.

4. Biological strains in Syngamus trachea.

After his work on the infectivity of various strains of *Syngamus trachea* to chickens, Taylor (1928) wrote :—" It is strongly suggested that *Syngamus trachea* shows a marked tendency to sub-divide into strains, each with a physiological adaptation to its particular host."

It is extremely difficult to generalise on the subject of the infectivity of various strains to the chicken since the susceptibility of the latter varies not only with its age but also to an enormous extent with the nature of its diet. In this it differs from the turkey, which is easily infected with " gapes " derived from various wild birds, the susceptibility to infection being apparently pronounced even in old birds.

In Taylor's experiments, chickens were fed directly with the infective larvae of gapeworm derived from starlings; the results showed infectivity to be low, 35 per cent. becoming infected in the first experiment and 10 per cent. in the second. When the eggs used were derived from original starling material that had already spent one generation in the chicken, the parasite had become adapted to its new host, and the infectivity of their eggs to other chickens was so heavy that five out of the eight experimental chicks died of the disease.

Morgan and Clapham (1934) showed that gapeworm from the rook can easily set up infection in the turkey, and the rook strain is also probably dangerous for young pheasants, but the results with chickens have been somewhat contradictory.

Whatever the difficulties that stand in the way of transferring *Syngamus trachea* from one host to the other, it must always be realised that these difficulties are obviated when the earthworm is used as intermediate host.

5. Resistance and Immunity to Syngamus trachea.

Fortunately for the poultry-breeder, the chicken acquires complete immunity to "gape" at the age of six weeks, and the presence of the parasite in one-year-old birds, though it has been known, is extremely rare. Thanks again to the admirable work of Dr. P. A. Clapham (1934), we know that gapeworm can easily be transferred to the older chickens if the birds' diet is either lacking in Vitamin A or in certain necessary elements, particularly Calcium. In her experiments, Miss Clapham found that 75 per cent. of the birds whose diet was deficient in either Vitamin A, or minerals, contracted "gape," whilst those kept on a natural diet were immune from infection. It is necessary here, then, to stress the importance of green food and such things as ground oyster, cockle, etc. shells in the rearing of young chickens, not only in connection with gapeworm but also as a means of protection against all parasites, particularly helminth.

6. Conclusion.

Modern researches have shown that difficulties of transference due to physiological specialisation among strains of *Syngamus trachea* are overcome by the utilisation of earthworms as intermediate hosts. Hence the gapeworms of wild birds can and do act as constant sources of infection for domestic fowls. The migrations of infected wild birds have definitely been proved to be the cause of the sudden outbreaks of disease that are so characteristic of the spread of the gapeworm. Several writers, particularly Lewis (1926), and Morgan (1931), have stressed the importance of starlings in this connection, and this opportunity is taken of stressing still further the importance of these birds as the primary factor in the dissemination of the disease. Every breeder is familiar with the myriads of starlings that flock to the poultry ground when hard winter conditions set in. Considering that these may be infected with *Syngamus trachea* to the extent of 35 per cent. as found by Dr. Lewis, it can be imagined to what extent the ground becomes contaminated in the course of a week of hard winter weather. Supplemented by an abundance of earthworms, ensuring ease of transmission, it can also be imagined what a potent factor this becomes when the young chicks are turned on to such ground in early spring.

Recent ornithologists, particularly Collinge (1927), stress the fact that the starling is not only increasing rapidly in numbers, but there is also a definite change occurring in its feeding habits. It shows an ever increasing tendency towards grain-feeding. Dr. Collinge estimates that cereals constitute 20.5 per cent. of its

food, a proportion that is alarming in the case of the Welsh farmer who only grows a very small acreage of cereals.

The changing habits seem also to drive this bird in increasing numbers to the chicken runs, to share the grain fed to the chickens, and in this manner materially aid in contaminating the land with the eggs of "gape." From every aspect the starling is becoming an important menace to the poultry industry.

ABSTRACTS, REVIEWS, AND BIBLIOGRAPHICAL NOTES.

ANIMAL NUTRITION.

Abstractor:

R. O. DAVIES, M.Sc., University College, Aberystwyth.

Animal Nutrition; Importance of the Mineral Constituents of the ration in.

A. JACOB. *Biedermanns Zentralbl B. Tierernährung* (1935), 7, 119-30.

It is pointed out that, whilst calcium and phosphorus are the chief mineral constituents of the animal body, considerable quantities of potassium are present in the bodies of young animals. From this, and the fact that the percentage of potassium is higher than that of any other of the mineral constituents of milk, the importance of this element to the young animal is emphasised. Manuring with potash salts results in an increase of potassium in the herbage, and balance experiments with cattle are reported in which ordinary hay and hay from potash fertilised fields were fed.

Dairy Cows; Effects of feeding low Calcium Rations to.

E. B. MEIGS, W. A. TURNER, E. A. KANE and L. A. SKINN. *J. Agr. Res.* (1935), 51, 1-25.

Cows which have been fed low calcium rates for nine months or more, readily utilize about 50 per cent. of the calcium intake for the production of milk and calves. It appears that, when the calcium content of a ration is reduced by substituting timothy hay or straw for alfalfa, the vitamin A content is also likely to be reduced, and that the failures in reproduction, which have occurred on rations in which the roughage was timothy hay or straw, are to be attributed to a vitamin A deficiency rather than to calcium deficiency. The physiological effects of rations which are deficient in calcium, though adequate in vitamin A, are in need of further investigation. R.O.D.

Dairy Cows; Sugar Pulp for.

J. Dept. Agr. I.F.S. (1935), 114-37.

These experiments indicate that sugar pulp, in the proper proportions, forms a suitable substitute for maize meal, in a mixed meal ration such as that fed to the cows in this experiment. R.O.D.

Dairy Heifers; The Phosphorus Requirements of.

J. G. ARCHIBALD and E. BENNETT. *J. Agri. Res.* (1935) 51, 83-96.

Retention of phosphorus by a group of heifers on a high phosphorus ration was superior at all ages to that by a group on a low phosphorus ration. The low phosphorus group made better use of the phosphorus they received, but not sufficiently so to equal the high phosphorus group in phosphorus storage. R.O.D.

Fasting Metabolism; A study of the—of various Breeds of Pig. II. Body Temperature Measurements.

T. DEIGHTON. *J. Agr. Sci.* (1935), 25, 180-91.

In fasting for from two to five days a reduction of body temperature was noted in a large majority of pigs, amounting in the average

to 1.7° F. It is concluded that hogs, like rats and guinea-pigs, are incompletely thermo-regulated animals. R.O.D.

Grass; A Comparison of the Feeding-Values of—ensiled by the A.I.V. Process and a Ration containing Mangolds and Hay.

J. B. E. PATTERSON. *Empire J. Expt. Agr.* (1935), 111, 144-52.

A feeding trial was carried out with South Devon dairy cows on the period reversal system: 40 lb. A.I.V. fodder replaced 40 lb. mangolds and 5 lb. hay. The milk yield during the A.I.V. fodder feeding period fell by 1.2 lb. per cow per week compared with values of 7.7 lb. and 4.4 lb. during the preceding and following control periods. There was a pronounced fall during the transition period when the cows were being brought on to the A.I.V. ration. This was only partly due to the change of ration, since the milk yield of the rest of the herd fell sharply at the same time, due to a severe spell of cold weather. The colour of the butter-fat was more than double during A.I.V. feeding. The live weights of the cows fell during the control periods and rose to slightly above the initial weights during A.I.V. feeding.

R.O.D.

Grass Silage.

J. P. DREW, G. F. O'SULLIVAN and D. DEASY. *J. Dept. Agr. I.F.S.* (1935), 1-22.

From the results of experiments on different methods of making grass silage it is concluded that grass silage produced by the natural fermentation method, when carefully carried out, is the most convenient, reliable and economical for general adoption where the grass must be cut at such a stage of growth that it can be handled by the ordinary farm machinery. R.O.D.

Grass Silage; Experiments on. 1. A.I.V. Silage.

C. BOYLE and J. J. RYAN. *Dept. Agr. I.F.S.* (1935), 33, 149-59.

An experiment on the making and feeding of A.V.I. Silage is described. It is concluded that the A.I.V. method reduces losses in dry matter due to respiration and fermentation to a very small amount. It is less adaptable, however, to normal farm routine than the ordinary method. The loss due to wastage on top, sides and bottom appears to be similar in both methods. Further experiments on the A.I.V. and ordinary methods are being carried out, and the molasses method is also being investigated. R.O.D.

Herbage; The Comparative Digestibility of Artificially Dried Pasture by Sheep and Rabbits.

C. J. WATSON and W. GODDEN. *Empire J. Expt. Agr.* (1935), 111, 346-50.

Digestibility trials were conducted with four rabbits and two sheep on an artificially-dried pasture herbage of five weeks' growth. The rabbits did not digest this herbage as well as the sheep. An important contributory cause of this was the inability of the rabbits to make efficient use of the crude fibre fraction. R.O.D.

Lucerne; Nutritive Value of,

III. The Composition, Digestibility and Nutritive Value of Lucerne Hay, Lucerne Meal (English and American) and Lucerne Leaf Meal (American).

H. E. WOODMAN and A. EDEN. *J. Agr. Sci.* (1935), 25, 50-70.

A good grade of lucerne hay made from a crop in early flower has a starch equivalent almost the same as that of a good grade of meadow hay. It tends to be rather more fibrous, but is nearly twice as rich in digestible protein and almost three times as rich in lime.

Manufacturing processes for the production of lucerne meals are described. The composition of these meals resembles very closely that of the lucerne crops used in their manufacture. The manufacture of lucerne meal by grinding the hay resulting from sun-drying may involve all the disadvantages associated with the conversion of lucerne into hay. For the production of lucerne meal of highest digestible protein and starch equivalent content, it is necessary to collect the crop in the green condition and to dry it artificially.

The results emphasise the relatively high digestibility, digestible protein content and starch equivalent of lucerne leaf meal, and show that it closely resembles the whole meal made from lucerne at the pre-budding stage of growth. R.O.D.

Minerals in Relation to Disease of the Larger Domesticated Animals.

H. H. GREEN. *Empire J. Expt. Agr.* (1935), 111, 368-77.

A brief survey of the dietary significance of minerals is given with reference to diseased conditions in the animal. R.O.D.

Nutritive Value of Lucerne. IV. The Leaf-stem Ratio.

H. E. WOODMAN and R. E. EVANS. *J. Agri. Sci.* (1935), 25, 578-97.

Data are given concerning the ratio of the amount of leaf to stem in the lucerne crop at different stages of growth, and the separate composition of the leafy and stemmy fractions. The leaves display throughout the whole period of growth a much higher degree of uniformity in protein and fibre content than the stems. They are also definitely richer in ether extract and slightly richer in N free extractives. The difference in composition between leaf and stem is also pronounced in respect of mineral constituents, the leaves, particularly in the stages of bud and flower, showing the higher ash content. The amount of ash in the leaves undergoes little change with advancing growth of the crop, while that of the stems suffers considerable reduction.

R.O.D.

Oat Hulls; The Food Value of.

E. J. SHEEY. *J. Dept. Agr. I.F.S.* (1935), 33, 167-72.

The comparative food values to young cattle of white oat hulls and of good quality meadow hay have been determined. Both the hulls and hay were fed in conjunction with sugar beet molassed pulp, and in the group experiment a protein and mineral supplement was also included in the diet. Eleven parts by weight of oat hulls had a nutritive value similar to eight parts of hay. Oat hulls may be conveniently fed to cattle in a mixture with steeped sugar plup. Such a mixture, supplemented by a small quantity of proteins and minerals, provides for satisfactory progress even in the case of young cattle. R.O.D.

Pasture Studies VII. The Effect of Fertilization on the Nutritive Value of Pasture Grass.

E. W. CRAMPTON and D. A. FINLAYSON. *Empire J. Expt. Agr.* (1935), 111, 331-45.

The results of these investigations suggest that the explanation of the differences in nutritive value of the herbage from fertilized versus unfertilized pasture lies partly in their amino-acid make-up. In the herbage from these pastures cystine alone is not the limiting factor in their nutritive value. R.O.D.

Pig; Carcass Quality of the Pig in relation to Growth and Diet.

E. H. CALLOW. *Empire J. Expt. Agr.* (1935), 111, 80-104.

The effect of diet on the rate of growth of the pig, and on the chemical composition of the deposited fat is discussed. Diet plays an extremely important part in carcass quality at all stages of life. Foods containing large quantities of unsaturated oils tend to produce carcasses having soft fats. Special reference is made to feeding cod liver oil and the possible onset of rancidity subsequent to curing in the case of bacon pigs. R.O.D.

Pigs; The use of balanced and unbalanced Rations for growing.

C. A. MURRAY. *Rhodesia Agr. J.* (1935), 32, 116-8.

In a small trial the economical effect of adding 10 per cent. meat meal to a ration of 100 parts maize meal and one part salt is clearly demonstrated. Other suitable rations for growing pigs are given. R.O.D.

Poultry Nutrition; Vitamins and Minerals in.

E. M. CRUICKSHANK. *Nutr. Abst. and Reviews* (1935), 5, 1-17.

Estimates of vitamin A requirements for both maintenance and egg production indicate that the fowl's requirements for this factor are considerably higher, relative to its body weight, than those of the rat. The evidence for the requirements in other vitamins by the chick is also discussed. R.O.D.

Protein; The Retention of by growing Pigs.

J. H. W. TH. REIMERS and L. H. BARTEL. *J. Agr. Sci.* (1935), 25, 397-418.

The retention of protein during different periods is given in tables and the percentages of retention are calculated. From these data the authors calculate the standards for protein at different ages of the animals. Standards for non-nitrogenous constituents have also been estimated and expressed in starch equivalents. R.O.D.

Swine; The Calcium, Phosphorus and Vitamin D Requirements of.

GEORGE DUNLOP. *J. Agr. Sci.* (1935), 25, 22-49.

The results of this investigation indicate that a diet with a calcium level of 0.45 per cent. of the dry matter and a Ca/P ratio of 1/1.3 is *optimal* when, as in practice, the average daily rate of growth between the live weights of 30 and 200 lb. varies from 1.0 to 1.4 lb. and the economy of gain from 3.0 to 4.0 lb. of dry matter per lb. of live weight increase. R.O.D.

Swine; The Effect of the Growth-Promoting, Appetite-Stimulating or "Physin" Factor on the Live-Weight Increase of.

GEORGE DUNLOP. *J. Agr. Sci.* (1935), 25, 445-58.

The growth promoting or appetite stimulating factor, physin, which has been shown to give rise to an accelerated growth rate in laboratory animals, produces a similar marked effect in swine when added to adequate diets of natural foodstuffs. The increased response is approximately 40 per cent. Physin acts through stimulating appetite and general growth. It does not enhance the net energy value of the ration. Most rations for swine in this country are grossly deficient in this factor.

The physin content of foodstuffs which may be used to supplement the diet of domestic animals can be arranged in the following order:—Liver, liver meal, dried whole milk, whey, green food, fish meal, meat meal or extracted soya-bean meal. R.O.D.

Swine; The Vitamin A Requirement of.

GEORGE DUNLOP. *J. Agr. Sci.* (1935), 25, 217-30.

The amount of Vitamin A necessary in the diet to keep the animals' reserves at their original level has been shown to be approximately 60 mg. carotene per 100 lb. of food. Alternatively, the Vitamin A requirement of a 100 lb. pig for maintenance and normal growth (1.3 lb. per day) is 4 mg. of carotene per day. R.O.D.

Wool-Growth in Sheep as Affected by the Carbohydrate content of the Diet. II.

A. H. H. FRASER and J. E. NICHOLLS. *Empire J. Expt. Agr.* (1935), 111, 75-9.

The addition of 1 lb. maize starch per day to the maintenance diet of growing Cheviot sheep doubled their wool production, and the increase was chiefly due to the greater thickness of the individual wool fibres.

The experiments show that although wool fibre is a protein substance, nevertheless under certain conditions its growth may be profoundly influenced by the carbohydrate in the sheep's diet. R.O.D.

Wool Production; Studies on the Relationship between Nutrition and ———— of Merino Sheep. I. The Technique employed for determining the utilisation of Foodstuffs and for estimating the Wool produced over short periods by Merino Sheep. II. The Effect of the Administration of Cystine, Cystein, Sulphur and of Methionine on the Growth of Wool of a Merino Ewe on a Protein-poor Ration.

H. R. MARSTON. *J. Agr. Sci.* (1935), 25, 103-31.

The administration of cystine to a sheep on a low protein diet was followed by a material increase in the growth of wool. The increase was trebled when cystein was injected subcutaneously so as to avoid destruction of the free amino acid by bacteria in the alimentary canal.

R.O.D.

ENTOMOLOGY.

Abstractor:

J. R. W. JENKINS, M.Sc., University College, Aberystwyth.

Aphides infesting the Potato Crop. IV. Studies on: Notes on the Migration and Condition of Alate *Myzus persicae* Sultz.

W. M. DAVIES and T. WHITEHEAD. *Ann. Appl. Biol.*, 22, No. 3 (Aug., 1935).

Further investigations in North Wales show that winged migrants from various crucifers are the main source of the initial infestation of *Myzus persicae* on potatoes. An account is given of the effect of wind, temperature, and humidity upon migration, and of the percentage virus infection conveyed by the migrants. The migratory population of a district known to suffer severely from potato virus diseases is compared with that of a district known to have been practically free from virus for the last seven years. J.R.W.J.

Aphis and Apple Scab. Bordeaux Mixture—Nicotine Combinations against.

M. D. AUSTIN, S. G. JARY and H. MARTIN. *J. S.E. Agric. Coll. Wye*, 36 (July, 1935).

An account is given of trials carried out to ascertain whether the addition of nicotine to two pre-blossom fungicide washes would give sufficient control of Apple Aphides to make the use of tar distillate washes in the dormant season unnecessary. The results showed that, although a lower aphid infestation occurred on the treated trees, the degree of control was less than that obtained by the use of tar distillates. J.R.W.J.

Capsids: Control of by Winter Spraying. With notes on "Red Spider" control.

G. L. HEY. *Fruit Grower* (Jan., 1936).

An account is given of large scale field trials to compare the efficacy of the miscible type of petrolium oil spray with that of the emulsion type, the only difference between the two sprays being the method of emulsification. The former type gave slightly better results than the latter, but does not mix so readily with hard or saline waters. Recommendations are given as to time and methods of spraying, and the concentrations necessary to obtain the optimum results. J.R.W.J.

Fruit Pests: their effect and Detection.

G. F. WILSON. *J. Roy. Hort. Soc.*, 60 pt. 12 (Dec., 1935).

The ways in which insects attack fruit trees and bushes, and the nature of the injuries they cause, are described. An outline is given of the life histories and feeding methods of the main insect groups, and details of their anatomy in so far as they affect their economic status are described. An appendix gives a list of the chief pests of hardy British fruits. J.R.W.J.

Glasshouse Crops; Insect pests of.

H. W. MILES and M. MILES. Demy 8 vo., pp. 174 plus 21 plates and 15 text figures. Surbiton, Surrey: H. C. Long, "The Birkins," Orchard Road, Hook (1935). 8/6 net.

This work meets a need hitherto uncatered for by any publication in the English language, and will be welcomed by all interested in

glasshouse cultivation. General conditions which influence the incidence and frequency of pests are discussed; all the most important pests are dealt with individually and recommendations given for their control; and a chapter is included on general methods of pest control in glasshouses. The volume concludes with two useful appendices, one giving an "Alphabetical List of Chief Glasshouse Crops with Associated Pests and their Characteristic Injury," and the other a selected Bibliography.

J.R.W.J.

GRASSLAND.

Abstractor:

C. Bryner Jones, C.B., C.B.E., M.Sc., Welsh Department, Ministry of Agriculture.

The Land Now and Tomorrow.

R. G. Stapledon, C.B.E., M.A. pp. xvii + 336, with illustrations and maps. Faber & Faber. Price 15/-.

This is not an easy book to review for the reason that its contents are so varied and the land is viewed by the author in so many different aspects. The book is not merely an admirable treatise on land improvements and a thoroughly sound guide in the application of modern methods of increasing production, but it is also much more. It is a philosophic disseration upon the land as a precious heritage, a possession to be regarded with pious care as well as an asset that the nation cannot be excused for neglecting. "Land improvement," says the author, "most assuredly is not only to be measured in cash returns, nor is the hope of ultimate gain by any means the only incentive to the breaking-in of new acres." While the question of cash returns is not overlooked and prominence is given to the need for research and for greater facilities and more generous encouragement for the scientific worker, the main theme of the author is to awaken the interest of the public in the wonderful potentialities of the land as a means of satisfying the spiritual, no less than the temporal, needs of the nation. The Shakesperian quotation which precedes the first chapter indicates the standpoint from which the author approaches the subject and the entire treatment is inspired by what the well-known words imply—"This blessed plot, this earth, this realm, this England."

Professor Stapledon is so well-known in connection with his work on grassland that a book bearing his name as author could not fail to attract many readers and the volume under review has already aroused such wide interest, both on account of the information it contains and of the spirit and manner in which it is written, as to secure for it a high place among the notable agricultural books of the past year. While, as already indicated, the book deals with many aspects of land improvement and of production from the soil, it is with the improvement of grassland and the possibilities of grassland as a source of increased production that the author is mainly concerned.

Owing to the policy adopted by the State in recent years, arable farming in England has received a good deal of attention and there has been a considerable revival of interest in it. But the bulk of the surface

of agricultural Britain consists of pasture of one kind and another and grass is by far the most important crop that the country produces. It is so partly because of economic conditions, the conversion of land once arable into pasture having been the farmer's method of adapting his system of farming to meet the altered conditions brought about by the times. But in the main the surface of Britain is predominantly under grass because of conditions which geography and climate have imposed upon it and which neither the farmer nor the State can change. For this reason it must be assumed that the grasslands of this country are a permanent feature of its rural economy. But while that may be accepted as a fact, it does not mean that our grasslands, as they are, contribute to the needs of the nation what they are inherently capable of doing if every grass field and every accessible hill in the country were given through scientific methods of management a reasonable chance of proving their capacity. Too often grassland is left to look after itself. It does not seem to be recognised that grass is a crop which responds, like other crops, to properly applied treatment, nor that such treatment is necessary if productivity is to be maintained. It is true that all grasslands will not respond to the same degree, for soil and situation are factors which must be reckoned with here as with other crops. But there are few pastures that will not respond in some degree and the striking results which have been obtained by Professor Stapledon, even in what many would have regarded as most unlikely places, are an ample proof that if all the grassland in Britain received due attention, agricultural production in this country would increase to an extent that is difficult to estimate.

While grass is a crop and is dependent, like other crops, upon the factors that regulate growth, it is, nevertheless, different from other crops in that it consists of a large variety of plants, which vary in their habits as they do in their value as food for stock. Grass, or pasture, therefore requires special treatment if it is to yield its best and its proper management involves a special technique. It is through the discovery of such a technique and its successful application in practice that Professor Stapledon has rendered such distinguished service to British agriculture. It is not too much to say that as a result of the work to which he has applied himself with so singular a devotion, there is now a new science of grass management of which he is the most authoritative exponent.

A great part of Professor Stapledon's book deals in detail with the improvement of hill pastures and is based upon his experience as the Director of the Welsh Plant Breeding Station, which is known throughout the Empire and beyond for its work on herbage plants. There are many thousands of acres of hill pasture in this country, which, though low in relative value, is of such enormous importance in connection with sheep farming that its improvement is a matter of national concern. The results of Professor Stapledon's methods in this connection are of unusual interest to hill farmers, who have problems to face that are unknown to lowland dwellers and are responsible for a very important share of the national output.

No one who loves the land with the deep devotion which it inspires in those who know it—its history, its traditions and its ways—can fail to appreciate this remarkable book. The reader will perhaps not agree with

all the views that are expressed in it, but he will certainly feel that here is something that should make him think. That is what the author wants him to do, for he knows that it is by making people think that his own vision is to be realised and his faith in the land justified.

C.B.J.

LIVE STOCK.

Abstractor:

A. D. Buchanan Smith, M.A., B.Sc., F.R.S.E., Institute of Animal Genetics, University of Edinburgh.

Blackface Sheep in Zetland; Attempted Improvement of the.

Ian E. Sandison. *Scot. J. Agr.* (1935), 18, 342-9.

The writer runs a flock of 400 Blackfaces on the farm of Houlland in Unst, the most northerly island in Britain. Up till ten years ago he had accepted what was considered to be the general method of improvement of a flock of Blackfaces, namely, the buying of a handsome sire whose ancestors had been well-bred and fed for generations, and of some nice-looking female sheep, and improving at the same time the pasture so as to bring it up to the necessary standard to carry these improved sheep. The writer had made several attempts to improve the hill pasture by applying artificials or by feeding the sheep. He then realised that there are far bigger questions to be faced than supplying phosphate and clover seed to a sward composed of heath, sedges, mat-grass and bent. He came to the conclusion that we have a long way to go in the hill-lands of Scotland before we can improve pastures economically, except by the minor methods of selective grazing and burning. As a result of his cogitations along these lines the author decided, in 1924, to change his methods of attempting to improve his Blackface flock.

It was useless to bring in good sheep unless the pasture could also be improved. This he had attempted without success. The thought of improving a hillside seemed stupendous. Accordingly, if the habitat of the sheep could not be improved, could anything be done with the sheep themselves? Could they be made to use the pasture to better advantage? Observations on the native Shetland sheep showed that they did not respond to first-class pastures showing clovers and foxtail in profusion, but that they kept in better health and condition on their native hills. Accordingly, remembering Darwin's theory of "the survival of the fittest," the author decided to let the hillside be the test, and to cull those sheep that had to be artificially fed. He selected from his own ewe lambs those which would best survive on the hillside and ran them out with as little hand-feeding as possible. The softer and fed sheep were marked in the spring and replaced in the autumn by selected hardy lambs.

After three or four years of this method, the appearance of the flock left much to be desired, but against this most of the sheep could feed themselves and their lambs, and the costs went down. By the sixth year there was an improvement in type, and a pen of his gimmers which

had never seen a feeding-box were placed second at the local Show. Since then there has been further improvement, and last winter only twelve ewes and two ewe hoggs out of a stock of three hundred and forty ewes and sixty ewe hoggs required to be fed, and those only for a few weeks.

During the ten years only one sire has been purchased. This tup was from a noted Scottish breeder, and had most of the required good points, except that he was small and short and rather like a "short muir" sheep with the black on the face tinged with brown. He could support himself and keep in condition, and transmit this characteristic to his progeny. He ran his first season in 1927 and his last in 1932—six years. The writer has not hesitated to inbreed to a much greater extent than he previously ever dared, and comes to the conclusion that provided always the sire and dam are of the best the results will be satisfactory.

In the year 1924-25 10 per cent. of his ewes died, and 24 per cent. of his ewe hoggs, while in 1933-34 the deaths amongst the ewes amounted to 4 per cent., and amongst ewe hoggs also to 4 per cent. In 1925 the number of barren ewes was 15 per cent., and in 1934 7 per cent. Part of the decrease in mortality of the ewe lambs can be attributed to Braxy vaccine. In 1927 hoggs were vaccinated in 1926 and turned out on to the lower hillside at the end of November. It may be thought that by vaccinating lambs the author departed from his method of the selection of the fittest. It must, however, be remembered that at no time has he been opposed to those forms of improvement which could be effected economically.

The author concludes that it is very evident that an all round improvement has been made in the flock simply by selecting breeding sheep that could thrive and fatten on the existing pasture. He is satisfied that as it is essential to run an engine on an oil for which it has been made if good results are to be obtained, so it is essential to feed a sheep on pastures to which it has been accustomed through generations of feeding. Considering the whole question of decreased fertility in sheep caused by the reduction of phosphate, lime, etc., the author wonders whether this is the whole explanation. After examining hill flocks in various parts of Scotland he cannot agree that the appearance of the sheep, and the lower stock-carrying capacity, can be fully explained by the selling-off of stock. He believes that the change is due to the reduced values of these pastures, *combined* with the decreased ability of the sheep to make use of the poorer grasses, so that there has been a very considerable decrease in the number of sheep in the Highland districts. Is not this principally due to the decreased ability of the sheep to use these grazings? Many readers will agree with the author when he states that Scotland requires a sheep for its native heaths and sedges, and that with skilful breeding and management the Blackface sheep is the most suitable animal to turn Scottish moorland and mountain pastures to profit. A.D.B.S.

Baconers; Analysis of Growth and Carcase Measurements of.

G. N. Murray. *Onderstepoort J. Vet. Sci.* (1934), 2, 301-60.

The object of the work described in this paper was to study the growth of baconers from every standpoint with a view to the provision of information for the time when bacon factories would start paying

for pigs on a quality basis. An analysis was accordingly made of the growth and carcase measurements of some 500 baconers out of Large Black sows. These fell into two groups, the one sired by Large White boars, and the others sired by Tamworth boars.

For thirty-nine farrowings the average gestation period was 118 days. The average birth weight of 494 pigs born alive was 2.89 lbs., the males being 2.99 and the females 2.78 lbs. respectively. There was found to be a continuous decrease in the birth weights of both sexes as the size of the litter increased. There are useful figures on the rate of growth, and these are discussed in relation to the other work which has been done.

With regard to the weight at four weeks as an indication of the weight at eight weeks, a positive correlation was found to exist of as high as 0.76.

The second part of the paper relates to the factory results, and is introduced by a Table showing the differences in the average and relative weights and measurements of the two crosses of pigs. For this purpose there were 156 Tamworth × Large Black Crosses, and 295 Large White × Large Black Crosses. These were taken to 194 lbs. and 196 lbs. liveweight respectively. Their factory weight averaged 178 lbs. for the group sired by the Tamworth, and 180 lbs. for the group sired by the Large White. Likewise there was little to choose as regards carcase weight, or the weight of the cured side. The average daily gain also showed little variation, being 1.306 for the Tamworth and 1.31 for the Large White. Again, in carcase measurements, there was little to choose between the two lots. The back fat of the Tamworth group measured, at its thickest point, 2.03 inches, while the Large White group measured 2.19 inches. The Tamworth sired also the thickest bellies.

Other results which emerged from this paper are that, although the average results of the two crosses do not show marked differences, there are large differences between the average results of the progeny of different boars of the same breed. There were found to be 24 per cent. more females in the higher grade than there were males. The heaviest pigs made the quickest gains, and had longer and deeper sides.

The correlation co-efficient between weight and length and between weight and depth are respectively + 0.48 and + 0.5. Barrows are deeper than females at the shoulder, but the latter are deeper at the flank. The barrows are fatter and have better marbling than the gilts, but the latter have better bellies.

Depth of side increases with rate of gain, but it has hardly any effect on the length of side. Back fat increases with an increase in the rate of gain, the correlation being + 0.35. Females have thinner back fat than males, but fatten at a more rapid rate, and so tend to approach that of the males.

For baconers, the writer considers that the optimum gain per day is between 1.2 and 1.49 lbs. Length cannot be significantly influenced by rate of gain since it is early maturing. The actual depth of side appears to decrease slightly when length increases, whereas the relative depth increases markedly. The longer the side, the less is the back fat likely to be. A.D.B.S.

Beef; Investigations on Producing Quality in.

J. Hammond and W. S. Mansfield. *J. Min. Agri.* (1936). 42. 977-85.

Some Irish Shorthorn heifers were purchased and run out on poor

heavy clay grass land on the University Farm, Cambridge. They were divided into four lots, each lot being served, during March and April, 1982, by a bull of a different beef breed—Hereford, Beef Shorthorn, Aberdeen Angus, and Sussex. During the in-calf period the heifers were on grass; and were brought into boxes about a month before calving in December, 1982, and January, 1988. After nearly three months in boxes the heifers and calves were run out to grass, no concentrates at all being given to them. The calves were weaned at the age of thirty weeks, and were then all feed together in one lot in a covered yard. They were " kept going " after weaning and never lost their baby flesh. At the end of the feeding period, when they were about sixteen months old (May 5th, 1934) they weighed on the average 900 lbs.

The carcases were marketed through the Ministry of Agriculture's Marketing Scheme, being weighed and graded by the Ministry's graders: special observations on the carcases were also made. The average live weight just before slaughter was 865 lbs., and the average dead weight 527 lbs., giving a carcase percentage of 61 per cent. of the live weight before slaughter. All carcases were graded select except two, which were named " super select."

The numbers of animals in each group were too small to give statistically significant results, but the authors obtained the impression that with strong-framed heifers the Aberdeen Angus bull did best. With light-framed heifers of the dairy type the Hereford and Beef Shorthorn were superior.

There are interesting observations on the quality points, some of which are noted here:—

A low carcase percentage is associated with an undesirable type of carcase. During the process of growth and fattening there is a large increase in carcase percentage because most of the weight added goes on to the carcase rather than on the offal.

It is noted that under the present cattle subsidy regulations it is an advantage to the owner of well finished cattle, giving a good carcase percentage, to market them on a dead weight rather than on a live weight basis. The authors also recommend that, in order to encourage the small well-finished bullock the subsidy should be highest for animals weighing under nine cwts. alive than for those weighing over this amount.

In addition to notes on " Grain," " Finish," and " Colour of the Fat and Flesh," there are some excellent illustrations dealing with the proportions of the carcase in animals at different ages.

A.D.B.S.

Blindness in the Pig.

F. Hale. (1934). *Proc. Amer. Soc. Anim. Prod.*, 126-128.

In many animals there is no doubt that the absence of the eye is due to an hereditary factor. The fact that in certain cases where blind pigs were reported intense inbreeding had been practised has led to the belief that blindness in the pig was also due to genetic causes.

The present paper shows quite clearly that one type of blindness in the pig is not primarily genetic in origin. The author points out that if Vitamin A is withheld from the ration of a human being, the subject will eventually contract a severe eye disease called Xerophthalmia.

At the Texas Agricultural Experiment Station a Duroc gilt had been fed a ration completely lacking Vitamin A for 160 days previous to

service, and for thirty days thereafter. She farrowed a litter of eleven pigs, all of which were born without eyeballs. Later two other gilts were fed a Vitamin-A-free ration with two controlled gilts which received the same ration plus one per cent. of Cod Liver Oil. The two gilts getting the Cod Liver Oil farrowed normal litters. One of the gilts on the deficient ration did not come in season, while the other failed to farrow at the end of the normal gestation period. A post-mortem examination indicated that the litter had perished at an early stage.

Two further gilts were placed on a similarly deficient ration, and after the first thirty days of their gestation period were given an abundance of Vitamin A in the form of Cod Liver Oil. The gilts farrowed ten and fourteen pigs respectively. In the litter of ten all were born without eyeballs. In the litter of fourteen there were various combinations of eye defects. Some of the pigs had no eyes, some had one eye, etc., but all were blind. Other defects were also observed, such as extra ears, cysts, cleft palates, misplaced kidneys and adrenal glands.

From this and other evidence it is clear that the blindness and other defects of these pigs were not due to hereditary causes but to a lack of Vitamin A in the ration. The important point to notice is that the deficiency occurred previous to and just after service.

A.D.B.S.

Colour and Vitamin A Content of Milk; Influence of Breed on.

W. M. Beeson. *Proc. Amer. Soc. Anim. Prod.* (1934). 54-6.

It is well known that the colour of milk varies according to the food consumed by the cow. It is equally well established that the different breeds of dairy cattle produce milk of very different colour. Studies on breed variations in the colour and the Vitamin A output of dairy cattle are fragmentary. In order to determine individual and breed variations under the same environmental and feeding conditions butter-fat samples were prepared from milk of individual cows from the herd of the University of Wisconsin. The breeds included Ayrshire, Guernsey, Holstein, Jersey, and Brown Swiss. The cows were fed in the University barn, and received the regular herd ration of concentrates, hay and silage. In comparing the colour (or carotene content) of the different breeds, the Guernsey butter was the highest or most coloured while the Ayrshire and Holstein were the lowest. The Vitamin A content was highest in the Holstein butter and lowest in the Guernsey butter. In other words, when the carotene was high, then Vitamin A tended to be low, and vice versa. When a large amount of carotene was added to the diet by feeding the cows on pasture or on fresh alfalfa hay, both the carotene and Vitamin A content increased rapidly. Thus, the total Viamin A activity of the milk was doubled.

This study indicates that there are definite variations in the degree of colour and in the Vitamin A content of milk from different breeds of dairy cattle. Both these constituents can be increased by feeding.

A.D.B.S.

Crossbreeding Pigs.

L. M. Winters, P. S. Jordan and O. M. Kiser. *Proc. Amer. Soc. Anim. Prod.* (1934). 218-20.

This work was started in 1928 by the University of Minnesota and carried out at two sub-stations in that State. The breeds used were

Poland-China and Durocs at one Station, and at the other Chester Whites and Durocs. Standard rations and methods of handling were followed at both stations throughout the experiment. Gilts only were used for breeding. The pigs were weaned at eight weeks of age and placed on self feeders. They were considered finished at 220 lbs. live weight.

As a result there are figures on 300 purebreds, 184 crossbreds, 117 double cross pigs (*i.e.*, crossbred × purebred, other breed) and sixty-one back-cross pigs.

No significant difference was found in regard to the birth, weight and the number of pigs farrowed alive. All three types of crossbreds reached market weight approximately twenty days earlier than the purebreds with which they were compared, and they made their gains on approximately 10 per cent. less foods. In discussing the results, the authors state that the consistency of the advantage of the crosses over the purebreds was very impressive since every group of crossbreds grew quicker and ate less than the purebreds with which they were compared. Of the different types of crossbreds, the most interesting was the back-cross, and some notes on this subject are included.

There are one or two interesting remarks on some colours which were produced by the different crosses. In one litter of Yorkshire × Duroc Jersey four of the pigs were mostly red, with more or less of a white belt, and one pig had numerous small black spots. The Chester White cross on the Duroc Jersey did not give clear white pigs, but very light sandy-coloured pigs, which, on casual observation, might be called white. A.D.B.S.

Dairy Cattle; Comparison of Lactation and Yearly Records of.
G. M. Harris, J. L. Lush and E. N. Shultz. *J. Dairy Sci.* (1934). 17, 787-42.

Under the Milk Recording Scheme adopted by the Ministry of Agriculture for England, the cows are primarily measured on the amount of milk they produce in the calendar year, starting October 1st. Under the Scottish Milk Records Association, the cows are recorded on their lactation yield. In America the Cow Testing Associations usually work with yearly records, and these are, as in England, translated by Breed Societies into lactation records as required. The purpose of this study was to answer the question as to whether the lactation record is more accurate than the yearly record of the Cow Testing Association. In other words, does the lactation record tend to repeat itself more closely year after year? And is it thus the better criterion upon which to base the culling or selection of dairy cows? Secondly, if the lactation record is more accurate, is this difference in accuracy sufficient to pay for the additional labour required in calculating this record from the yearly records available?

In order to be effective for selection purposes, past production records of a cow must furnish a fairly accurate measure of what she can be expected to produce in the future. The true value of selection by the use of records is dependent, therefore, upon how closely these records tend to repeat themselves lactation after lactation, or year after year as the case may be.

From the results of this study it may be concluded that the Cow Testing Association yearly record tends to repeat itself in succeeding years about as closely as does the lactation record. The authors, therefore, conclude that a general change to the lactation basis for selecting

dairy cows, proving dairy sires, etc., will not lead to any material increase in accuracy. Such a change, they state, would be hard to justify if it entails any appreciable amount of additional expense or trouble.

In conclusion they state that what is far more important is the conditions under which the records are made. They recommend that allowance for these conditions should be made wherever possible. The individual owner can do this to some extent, but the man who has only the production records, with no description of the conditions under which they were made, cannot even begin to make such allowances.

A.D.B.S.

Fecundity in Swine.

L. A. HENKE. (1935). *J. Heredity.* 26, 455-456.

This paper summarizes the records of a herd of swine maintained at the University of Hawaii during the past fifteen years. The herd includes Berkshires and Tamworths. One hundred and sixty litters were born, of which complete records are available. These were produced by fifty-two different sows, and sired by nineteen different boars. Correlation figures are given between numbers of pigs in litters, and the number in the litters from which their parents came.

The author concludes that his figures give little support to the theory that pigs from large litters consistently produce large litters.

A.D.B.S.

Genetics of Dairy Cattle.

A. D. BUCHANAN SMITH. (1935). *J. Dairy Res.*, 6, 272-81.

A review of recent research dealing with the inheritance of milk yield. The survey covers the past two years. The principal subjects dealt with are conformation in relation to production, pedigree, inbreeding, and the Progeny Test. A.D.B.S.

Golden Fleece; The Trek of the.

R. H. BURNS and E. L. MOODY. *J. Hered.* (1935). 26, 482-48 and 505-18.

This paper deals with the development of the Merino race of sheep and of all the breeds which have been evolved from the main stem. The origin of the Spanish Merino is a matter of controversy but it is probable that sheep of a fine wool type were introduced to Spain by the Phoenicians hundreds of years before the Christian era, from Asia, Africa, Greece, and Rome.

The various conquerors probably also introduced fresh blood, particularly the Romans and the Moors. The wool industry is a very ancient one in Spain, which flourished under the Roman occupation, 6 A.D. to 456 A.D. After the expulsion of the Moors about 1500 the Merino flocks passed under the control of the Sovereign, but during the subsequent religious persecutions the sheep and wool industries were sorely neglected and eventually the flocks were sold to wealthy Nobles and Church Dignitaries till ultimately they became more or less common property, with this characteristic that they had to travel far from one type of feeding to another during the year.

By the middle of the eighteenth century the other countries of Europe began to notice that sheep raising in Spain was the most profitable of the agricultural pursuits. Practically all the royalty of Europe lost

no time in asking favours directly or indirectly from their Spanish relatives. These were not always granted, and in certain cases, such as a flock for the King of England, the animals were smuggled out of the country. It was at this time that the Merino was established in Germany, where it has been maintained in Saxony till the present time. Economic conditions no longer favour this wool type, and there are only a few flocks left. Merinos were also developed in Silesia and in Prussia. In the latter part of the nineteenth century a number of breeders in Northern Germany started to breed a combing wool type, and imported animals from the French flocks at Rambouillet. It was these sheep, bred by Baron von Homeyer, that started the boom for Rambouillet sheep in the United States.

In Austria the sheep were established under royal protection, and to-day the flocks of both Austria and Hungary are primarily Merino in character.

Louis XVI of France made many mistakes, but the sheep industry of the world has him to thank for one very wise act. In 1783 he purchased the Rambouillet estate and established there an experimental farm for the acclimatization of animals and plants. He purchased some of the finest animals in Spain and established the flock.

The French were always much interested in mutton qualities, and from the first insisted upon this quality in the sheep at Rambouillet. There were a number of other flocks in France, but the term Rambouillet has now been applied to all French Merino sheep of the combing wool type regardless of their origin. The Mutton Merino is a somewhat different type.

It is in Australia that the development of this ancient sheep breed has reached its acme. The original importations were made about 1820. South Africa began importing in 1724, South America in 1794, and Russia in 1802. The final section of this work is devoted to the Merino in the United States. A.D.B.S.

Inbreeding Poultry.

Ministry of Agri. Bull. No. 83. (1934).

This Bulletin covers the work done at the Poultry Research Station at Reaseheath. The object of the investigation was to determine whether it was advisable for the average poultry farmer, who was breeding for high egg production, to follow a policy of inbreeding. The results show that, however useful it may be for fanciers, the policy of inbreeding is not one to be adopted by the average commercial poultry breeder. The answer is clear and unequivocal.

Two systems of inbreeding were employed, one involving the mating of a selected cock with his own daughters; in the other method the cock was mated to his sisters and then to his daughters. At the same time outbred controls were kept going. So far as possible fresh blood that was brought into the flock consisted of good birds, such as any progressive commercial breeder would purchase.

The experiments cover three breeds, White Wyandotte, Rhode Island Red and White Leghorn. During the latter years of the experiment the White Wyandotte was the only breed employed.

As regards the average annual production, that of the control progeny was greater than that of the inbred progeny for each of the breed in almost every instance. The whole evidence points to the conclusion that the annual production of the progeny of unrelated sires and dams is

greater than that of the progeny from the same sires mated to their daughters.

There was considerable variation in the degree of infertility in different years, and no conclusions can be drawn. The control stock had, on the whole, a better hatchability than any of the inbred stock. Likewise the percentage of chicks that were reared was higher for the controls than for inbreds. Other figures relate to age and weight at sexual maturity, and mortality in laying houses. Complete tables are given of the various results, which are treated adequately from a statis tical standpoint. The whole Bulletin is clearly written in a manner well within the understanding of practical breeders, to whom it can be thoroughly recommended. A.D.B.S.

Inbreeding Swine.

R. E. Hodgson. *J. Hered.* (1935). 26, 209-17.

The University of Minnesota has succeeded in making full brother and sister matings of registered Poland China swine for eight successive generations without any marked loss of vigour, and the indications are that at least two lines can be carried on indefinitely. The work was started in 1924, when six in-pig sows were purchased and an attempt was made to develop five inbred lines from these. Three of these lines were lost in the first generation, one in the third, and the fifth was carried to the fifth geeneration, but the type proved undesirable. Accordingly, two new lines were started in 1926, one of which is in the sixth generation and the other in the eighth.

As already stated, the matings were always brother and sister, and all matings were made under observation, the individuals being separated at other times. Several boars, particularly those of the second and third generations, showed reluctance to mate with litter sisters. Males quick to serve unrelated sows were completely indifferent to litter mates. Boars have identified litter mates instantly even in a lot of twenty-five gilts, and after having been kept on different farms for over six months. Perfume, paraffin and other ideas were ineffective in preventing recognition. Since the fifth generation there has been less difficulty in securing matings, and pregnancy has almost always resulted from satisfactory services.

The average litter size for the entire inbred population is 7.1, and shows no sign of decreasing. The inbred pigs are equally heavy at birth with the average pigs at the Minnesota Station. Weaning number is a point on which there is some interesting data. In one line the percentage of pigs surviving has been much lower than in the other lines. The writer concludes that temperament has been a much bigger factor than vigour in affecting the survival of a litter.

For the sixteen weeks the growth rate of two of the inbred lines equalled that of the non-inbreds. The third line was definitely slower. After sixteen weeks the non-inbreds came away more rapidly. As regards economy of live weight gain, the different inbred lines show a variation, but one line appears definitely better than the average of the pigs tested under the Swine Record of Performance project at Minnesota Station. The carcase grading of the inbred pigs is above the average. There were some abnormalities in colour, but there were no hernias, and only two cryptorchids produced.

Dealing at some length with temperament, the writer states that one line showed the characters to be expected in the wild ancestors of

modern swine. So long as the sow was not interfered with she was likely to bring her young up. The opposite type of disposition was found in another line where the individuals were easily handled and always friendly. In this line excessive losses were experienced because of the extreme indifference of the old sows to the squeals of their young.

In 1931 three outbred sows were mated to an inbred boar while three other sows, the litter mates of the first three, were bred to the regular herd boar in use at the Minnesota Station. The pigs by the inbred boar made greater daily gains on rather less feed and were more uniform in type. Crosses were made between the three lines and contrasted with non-inbred pigs born at the same time. There was no difference in the average birth weight, but the pigs from the crossbred lines reached maturity (200 lbs. live weight) four weeks earlier than the non-inbred pigs. In connection with this it must be remembered that the advanced generations of inbred pigs require about twenty days longer than the non-inbred to reach 200 lbs. live weight. Thus the pigs produced by crossing two inbred strains reached the weight nearly seven weeks earlier than the inbreds. This point is of supreme importance as being the first instance in animal production of a phenomenon not unknown in crop production, particularly in maize. The principle may possibly form a basis for livestock improvement in the future. A.D.B.S.

Jersey Cows; Frequency of Milking as Affecting Milk and Butterfat Yields of.

L. Copeland. *J. Dairy Sci.* (1934), 17, 815-22.

When Jersey cows were milked three times daily there was a resulting increase of approximately 19 per cent. in butterfat and 21 per cent. in milk yield. This increase in yield, due to milking three times daily, varies greatly with the producing ability of the animal on twice a day milking. High producing cows show a smaller increase in yield when milked three times daily than do cows with a lower inherited producing ability. In view of this variation in the individuality of the cows, the writer does not recommend the use of a single factor for converting all records made with twice a day milking to a three times a day milking basis.

An analysis of the data presented here shows some interesting side lights on the physiology of lactation. This fact, that the lower yielders with twice a day milking made the bigger response, is in almost direct contrast to popular opinion among many dairymen. It has been shown elsewhere that as the udder fills with milk, the pressure exerted by the milk tends to check secretion. This accounts for the fact that cows yield greater quantities of milk when milked oftener than twice a day. Yet, according to this reasoning, high producing cows ought to show a greater increase than average producing cows when they are milked three times daily. The writer also states that milking heifers three times daily results in a slightly greater development than when the records are made on twice a day milking. He comes to the conclusion that the mass testing of cows on twice a day milking will definitely differentiate between average cows and high producing cows of the breed. A.D.B.S.

Jersey Cattle; Wrytail in.

F. W. ATKINSON and T. R. WARREN. *J. Hered.* (1935), 26, 331.

In cattle, when the base of the tail is set at an angle to the backbone, the term wrytail is used to describe the condition. The abnormality has also been observed in horses, pigs, and poultry. The authors of this paper have noted many examples in the Jersey breed. When several wrytailed calves, all sired by the same bull, appeared in one herd of registered Jersey cattle, the question of whether this was a heritable defect presented itself. In all the animals examined in this study the base of the tail was set to the left. From correspondence with breeders it appears that a similar character occurs also in Guernseys to a lesser extent, and possibly also in Holstein Friesians, Ayrshires, and Brown Swiss.

In this paper three consecutive generations of normal bulls have been proved to be carriers of the genetic factor for this character. From the evidence adduced, wrytail appears to be inherited as a simple recessive.

A.D.B.S.

Lactation; Effects of Pituitary on.

ASIMOFF and others. *Trans. Endocrin. Lab. of the All-Union Inst. Animal Breeding* (1934), 108-18.

Evans' extract of the anterior lobe of the pituitary gland was tested on dry and lactating cows. From this work it has been noted that a hormone exists which exercises a direct influence on the mammary gland, and that this hormone is found in the anterior lobe of the pituitary. The increased yield of milk as a result of these injections remains for only two to four days, after which production appears normal. The doses must be fairly big, since small doses were not found to exercise any effect. The extract only had an effect in the normally developed mammary tissue. It produced no effect on cows which had been dry for a long period.

A.D.B.S.

Mammary Glands of the Udder of the Dairy Cow; Individuality of the.

C. W. TURNER. *Univ. Missouri Res. Bull.* 211 (1934).

Dr. Turner designed a milking machine capable of delivering into separate containers the milk secreted by each of the four quarters of the cow's udder. He found that the two front quarters each produced slightly more than 20 per cent. of the total milk yield. The two rear quarters each produced slightly less than 30 per cent. The milk production from the right and left halves was practically uniform. It can thus be reckoned that 40 per cent. of the yield of milk of a cow comes from her two fore quarters, while 60 per cent. comes from her two hind quarters.

Studying the lactation curves of a group of Holstein and Jersey cows, it was found that the general trend in the rate of milk secretion by quarters was quite uniform throughout the entire lactation period. Considering the average of each breed separately, no tendency was observed for either the front or rear quarters to secrete milk richer in fat than the other, even though there was considerable difference in the average yield of milk.

A.D.B.S.

Mastitis in Cattle; Susceptibility to Acute.

W. T. WHITE and H. L. IBSEN. *J. Hered.* (1934), 25, 489-90.

The Alaska Agricultural Experiment Station has for long been crossing the Holstein with the Galloway in order to produce a hardy cow. Calves of the fourth and fifth generation are now being born. During the course of this experiment, three cases of acute mastitis occurred among related animals. This suggested the possibility that susceptibility to this disease is inherited. Except for these three cases, no example of mastitis of such marked virulence has been found in any of the several hundred other cows bred by the Alaska Station. It has been estimated that about eight cows per thousand per year have the acute, or clinical, type of mastitis. It has also been observed that this acute type rarely spreads through a herd. It occurs in isolated instances and, although the cow has been in the milking line previous to infection, adjoining cows rarely become infected. The sub-clinical (sub-acute, chronic, latent, etc.) form of mastitis is much more prevalent and may vary in a herd from 20 to 90 per cent. of the individuals.

This paper includes a discussion of the problem, and the material as presented appears to agree with the assumption of the authors that predisposition to acute mastitis is inherited; it would appear legitimate to assume that one or more dominant genes are responsible for that susceptibility.

There is the possibility that susceptibility to the milder forms of mastitis is also inherited. Hitherto a genetic basis has not been considered to be a principle cause of mastitis in cattle. This paper clearly shows the need for investigators to be awake upon this point. Mastitis is one of the most objectionable diseases which at present beset dairy herds. If a susceptibility to the disease is definitely proved, then it will mean that the trouble can be better eradicated by breeding methods than by attempting to control infection.

A.D.B.S.

Mating Rams to Angora Goats.

B. L. WARWICK, R. O. BERRY and W. R. HORLACHER. *Proc. Amer. Soc. Anim. Prod.* (1934), 225-7.

In order to determine whether hybrids could be produced from Angora goats and the sheep common to Texas certain matings were made. It was soon found that some of the Angora female goats became fertilised by rams, but that the embryos perished before the end of the gestation period.

The first matings were made in November, 1930, and two female goats became pregnant and showed signs of abortion. The herd was tested for Continuous Abortion, but there were no reactors. In subsequent years the female goats were killed at various stages, and the foetuses were recovered.

The rams used included Rambouillet, Merino, and Dorset x. The Merino rams were the most successful, one of them having been raised by a goat as foster-mother.

Contrary to popular opinion, the Angora male goats would not mate with ewes. The writers have accordingly raised a young billy-goat on a sheep as foster-mother. He has been mated with hopeful results.

The remainder of the paper discusses the scientific aspects of the subject.

A.D.B.S.

Meat Production; The Problem of Quality in Relation to.

J. HAMMOND. *Scot. Journ. Agric.* (1936), 19, 24-8.

This paper discusses market trends in the type of meat demanded by the consumer in respect of both beef and veal, mutton and lambs, bacon and pork. The writer is of the opinion that if the British farmer is to obtain a share of the market for meat in this country, he should be prepared to supply a product of the highest quality and be paid for his meat on this basis. In his opinion the present beef subsidy does nothing to increase the popularity of British beef with the consumer. It encourages the production of heavier and incompletely finished beasts, which give large joints and tough meat. In a permanent plan the subsidy should provide a higher scale of payment for the lighter weights than for the heavier, and within each of those weight classes give a higher payment for good quality than for low quality. A.D.B.S.

Pigs; Production Records for Selecting.

E. F. FERRIN. *Proc. Amer. Soc. Anim. Proc.* (1934), 112-4.

This paper deals with the methods of pig recording and litter testing in Europe, and formulates the plan adopted by the National Association of Swine Records of America and the National Swine Growers' Association. This plan provides for the weighing of all pigs when they are weaned at fifty-six days. Litter markings, dates of farrowings, and the percentage of the litters will be checked by a supervisor who will personally weigh each litter of pigs between fifty and sixty-two days of age. Carcase tests will be made of as many of the marketed pigs as possible, and the scheme will be under the general supervision of the State Agricultural Colleges. A.D.B.S.

Poultry; Disease Resistance in.

V. S. ASMUNDSON. *Fifth Pacific Sci. Congress* (1934), 2569-72.

Mortality among poultry in commercial flocks has been increasing in America as in other countries. The causes of death fall into two main groups, infectious and non infectious. Previous workers found that 65 per cent. of the chicks of a strain resistant to pullorum disease survived artificial inoculation with the organism, whereas only 28 per cent. of the chicks of a susceptible strain survived such treatment. Likewise, of a group of birds selected for their resistance to fowl typhoid, only 10 per cent. went down with the disease as against 90 per cent. of ordinary birds. Additional evidence is in favour of the view that resistance to fowl paralysis is also inherited. In this case it is determined by one pair of factors.

The writer concludes as follows:—" Care should be taken, of course, to avoid introducing diseases with purchased stock. Aside from this, it is sometimes found that stock which presumably represents the best that is available proves disappointing in the new environment. There are two possibilities here. One is to breed to meet local requirements, the other is to set higher standards so that the birds will be able to withstand a wide range of conditions. Whichever procedure is followed, it will require greater emphasis on pedigree breeding and progeny testing (family analysis) if breeders are to do their part in reducing losses among poultry flocks." A.D.B.S.

Poultry; The Influence of Thyroid and Parathyroid on Plumage of.
R. Prawochenski and B. Slizynski. *Proc. Zoo. Lab., University of Krakow.* (1935).

Thyroid preparations fed to hens gave striking results. On the eighth and ninth days the hens began to lose their feathers. On the twelfth day there was the full appearance of moulting. From this, and other experiments, with the Parathyroid quoted herein, the authors are of the opinion that there is an antagonism between the secretions of the two glands. A.D.B.S.

Reproduction in the Sheep.
R. T. Clark. *Anat. Rec.* (1934), 60, 125-51.

The object of this investigation was to attempt to determine the fundamental factors influencing the phenomenon of twinning in sheep. The paper includes an interesting review of the whole subject, discussig prolificacy both from the genetical and environmental standpoints.

The experiment conducted by Dr. Clark is based on forty grade western ewes, two-and-a-half years old and over. These were divided into two equal groups, Group I being subjected to a high plane of nutrition, whereas Group II was fed a ration designed to maintain them as close as possible to their initial rate. Each ewe was mated twice, and the ewes were thereafter slaughtered. Immediately after slaughtering the reproductive organs were examined. A second experiment on the same plan consisted of forty pure bred Shropshire ewes from the University of Minnesota, divided into two similar groups.

In the first experiment the flushed group produced more eggs than did the unflushed group of ewes. In the second experiment, where the Shropshire ewes were in a relatively high condition at the beginning, the flushed group did not produce as many eggs as the unflushed. It can thus be inferred that the condition of the ewes at the beginning of the experiment was an important factor in determining the response to the imposed environmental conditions. For this reason it is unwise to apply intensive flushing to a flock which is in a high condition. Dr. Clark therefore comes to the conclusion that the practice of flushing will lead to a higher ovulation rate, provided the ewes are not in a high condition to start with.

He also found that gain in weight of itself is not necessarily indicative of a higher ovulation rate. Furthermore, flushing appears to have no likely effect in bringing ewes into " heat " faster, provided their oestrous cycles have already been established.

With the same material Dr. Clark has made a study on the development of the egg in the ewe. The flocks were watched carefully during the entire period of the investigation. In order to ensure a high percentage of successful matings and to have an accurately timed series, the approximate time of ovulation was ascertained by destroying a number of ewes at different intervals during the period of " heat." Ovulation was found to occur rather late in the " heat " period. Hence, matings were made at the close of the second day after the ewe first showed signs of oestrous. The ovulation averages (number of eggs) produced was pretty much the same as the lambing percentage of the Shropshire breed.

The greater part of the paper is technical in that it discusses the development of the egg. The author confirms that the ova do not migrate from one uterine horn to another in sheep as in the case in

pigs. In this investigation the period of the oestrous cycle varied from thirteen—eighteen days, with an average of 16.4. The actual length of the period of " heat " ranged from less than twenty-four hours up to seventy-two hours, with the majority falling between thirty-six and forty-eight hours. No difference was observed between the groups with respect to time of coming in heat.

With regard to the rate of the development of the egg, Dr. Clark shows that the first cell division takes place between thirty-eight and thirty-nine hours after service. The second and third cell divisions follow the initial one very quickly, the four and eight cell stages being found at forty-two hours after service. Sixteen-cell stages were recovered at sixty-five hours after service, and the fertilised eggs passed into the uterus between seventy-seven and ninety-six hours after service. The thirty-two cell stage is reached about ninety-six hours after service.

The size of the unsegmented egg is larger than that of the cow, pig or rabbit. There is, however, a remarkable degree of similarity amongst the eggs of these animals, which become all the more impressive when the relative body sizes of the various species are considered.

A.D.B.S.

Reproduction in the Sheep.

W. W. Green and L. M. Winters. *Anat. Rec.* (1935), 61, 457-69.

The time that a ewe sheds her eggs is an important practical point in order to determine the best time for service. Allied to it is the question of the rate at which the sperm travels. The apparently short functional life of the mammalian reproductive cells shows that the best time for mating is relatively short.

In the present study twenty grade Shropshire ewes were tested for heat by placing the ram with them four times daily. The animals were mated as late in heat as was possible, firstly to reduce the source of error in sperm travel, and secondly to make use of the ewe for determining the time of ovulation as well as for sperm travel. The ewes killed and dressed by the usual method. The various cases are referred to in detail. From this work the authors conclude that ovulation in the sheep occurs late in the heat period, as the animal is passing from heat. The life of the egg is short, probably less than twenty-four hours. The time required for sperms to fertilise a suitable ewe took approximately five hours. The writers conclude that the reproductive tract of the ewe in heat gives no special response at copulation which tends to accelerate the advance of the sperms. In general, sheep sperm do not live more than tewnty-four hours.

The writers conclude that the best time for mating sheep is during the last five or six hours of the heat period. A.D.B.S.

Skin Defect in Cattle; An Inherited.

W. M. Regan, S. W. Mead and P. W. Gregory. *J. Hered.* (1935), 26, 357-62.

Jersey Cattle; A Lethal Gene in.

C. W. Wipprecht and W. R. Horlacher. *J. Hered.* (1935), 26, 363-8.

It would appear that both these papers reported the incidence of the same defect in different herds of Jersey cattle. The paper by Regan and others is the first to report this particular defect in Jersey cattle, which appears to be the same as one previously described by Hadley

in Holsteins. It is not the same as that described by Mohr and Wriedt.

Four hairless calves were produced in the herd of the University of California in the course of an inbreeding experiment designed to study the mode of inheritance of characters responsible for milk secretion. Three (two heifers and one bull) were born alive, parturition being normal, though the calves were born about three weeks before time. The fourth calf died in utero. All the calves had the same general appearance. Not only were parts of the body hairless, but there was no skin below the knees or hocks, around the eyes, or on the muzzle. In all cases one, or both, ears were deformed. The anus of one calf was completely closed. The other had no vulva. Of the three calves born alive one lived six hours; the other two were destroyed about fifteen hours after birth. None were able to stand. All appeared normal in size for the breed. The character would appear to be inherited as a simple recessive. The remainder of the paper outlines a breeding programme which is designed to eliminate the defect.

The second paper from Texas would appear to deal with precisely the same character again in Jerseys. The description of seven calves is approximately the same as that of Regan and his co-workers. In the second paper the description includes a greatly shortened lower jaw, lacking teeth, eyes sunken, abnormal ears, with flesh covering the head, hairless areas over body, and no hair below knees and hocks. The history of the herd also points to this character being inherited as a simple mendelian recessive. The character is not sex-linked.

Preceding these articles there is a note from the Editor (page 355) on " The Relationship between Hairless Calves in the California and Texas herds." When a study is made of the pedigrees of the two " suspect bulls " in the California and Texas herds it becomes clear that we are not dealing with a case of paralled mutation but with two appearances of the same defective gene. This evidence is practically conclusive. It is not quite certain whether the defect is identical with that reported by Hadley in the Holsteins. The Editor points out that should subsequent experiment prove the defect to be the same, the question of the origin of the mutation presents a further problem. The importation of cattle to the Island of Jersey for breeding purposes has long been prohibited. According to some authorities this ban has been effective for five hundred years. The possibility of a reciprocal transfer of Jersey cattle to Holland is perhaps greater. The suggestion by Atkeson and Warren that Wrytail character is most common in Holsteins and Jerseys may also indicate a certain community of genes in the two breeds in spite of their different colour patterns.

A.D.B.S.

Sterility in Cattle and Pigs; Feeding Sprouted Oats to correct.

L. A. Henke. *J. Agric. Res.* (1935), 51, 51 61.

These experiments were conducted at the Hawaii Station. The paper reviews the preliminary work (which has been previously reported in these columns) on the feeding of sprouted oats as carried out by the Bureau of Dairy Industry. The author points out that a definite conclusion could not be drawn from these experiments owing to the fact that there was no controlled group. In his own experiments the early

work with feeding sprouted oats to sterile animals gave rather favourable results. A controlled experiment was therefore started and seventy-five cows with irregular breeding behaviour were placed into two groups. Of these thirty-eight were fed sprouted oats, and 82 per cent. of them produced calves. Of the remaining thirty-seven cows which were not fed sprouted oats, seventy-six per cent. produced calves. In general this experiment does not demonstrate any definite value of sprouted oats for combating sterility in cows.

Of fifteen oat fed sows, 87 per cent. produced litters. Of sixteen control animals, 75 per cent. produced litters. In addition, three of five sows that failed to conceive for a long period in the control group were fed sprouted oats, and subsequently produced litters. There is thus some evidence that feeding sprouted oats may be of some value, but this evidence is by no means conclusive.

The author states that all the cows and all the sows, including both oat fed and control groups, received ample green feed daily, generally obtaining at least 1 lb. of green alfalfa or other green feed per sow per day. A.D.B.S.

Swine; Congenital Defects in the Mammae of.

J. E. NORDBY. *J. Hered.* (1934), 25, 498-502.

Any significant variation from the uniform spacing of nipples in pigs is most undesirable. It is not unusual to find too much space in front of the first pair of nipples and a crowd of teats towards the rear. It all probability the arrangement of teats is influenced by heritable factors. Likewise there are many variations in the shape of the individual teats. Some of these do not particularly influence functional efficiency. On the other hand there are some shapes that seriously affect the ability of the nipple to function normally. In a number of cases nipples that may appear inverted when the female pig is five or six months old develop later to the normal length.

Total suppression of nipples in swine is common, and similar defects have been reported in cattle and the human.

The present paper describes various defects, and deals more particularly with the inheritance of inverted nipples, which the author describes as resembling a pit or crater in the breast. These inverted nipples do not seem to be associated with a lack of gland development.

The defect has been observed for a number of years, and was particularly noticeable in one line bred strain. From the data available, there can be no doubt that the defect is inherited and that the hereditary influence probably functions as an inhibitor to normal nipples. These hereditary inverted nipples cannot be put right by practical means of manipulation. In order to eliminate the defect, the authors recommend that no animals should be used for breeding that are possessed of inverted nipples or that are the progeny of such parents, or that are themselves the parents of affected offspring. A.D.B.S.

Taint in Milk owing to the Feeding of Molassed Beat Pulp.

H. T. CRANFIELD and J. MACKINTOSH. *J. Min. Agric.* (1935), 42, 551-60.

This paper deals in general with the causes of taint in milk due to molassed beat pulp. The authors find that certain cows appear to be more subject to the production of tainted milk than do others. They state that different cows have varying capabilities as regards the prevention of any taint-producing compounds gaining access to the milk.

They state that the incidence of this factor cannot be measured, and that it is not possible to say to what extent the results at the different centres have been influenced by the animals used. They note the further fact that at one centre fishy samples were obtained from two cows not receiving molassed beat. A.D.B.S.

Thyroxin in Milk Secretion; The Influence of.

E. L. Jack and S. I. Bechdel. *J. Dairy Sci.* (1935), 18, 195-206.

Gradually the various organs which affect the secretion of milk are being studied. In a recent abstract reference was made to the use of an extract of pituitary as a means for increasing milk in low yielding cows. The conclusion to be drawn was that the pituitary plays an important part in milk yield. Recently some Italian workers (Calabro and Fantozzi) found that feeding thyroid and thyroxin extracts to goats increased their yields of milk. According to this study the thyroid also increased the fat content of the milk. Thus, two more glands are shown to play their part in milk yield.

The paper under review deals with the thyroid. The authors point out that it has already been shown that the removal of the thyroid causes a rapid decline in milk secretion, while the feeding of thyroid to cows whose glands had been removed brought the milk yield back to the level before the operation. Thyroid feeding to normal cows caused a rise in milk flow when the rate of lactation was falling, but was ineffective when the curve was rising or at its peak.

The present study was designed to determine the effect of injections of thyroid (thyroxin) upon the quantity and composition of the milk secreted by dairy cows. Four cows had thyroxin injected into their veins. Two were Brown Swiss, and two were pure-bred Holstein Friesians. The composition of the milk was not significantly altered as regards any of the qualities studied, and these included specific gravity, fat content, and the percentages of lactoglobulin, lactalbumin, protein, and lactose. The most significant change noted was the increase in milk yield in all cases following the administration of thyroxin. As an instance, in one cow a dosage, calculated to be equivalent to a 10 per cent. increase in the basal metabolic rate, resulted in an increase in milk yield of 11.2 per cent. The effects were gone within ten days of the conclusion of the treatment. Where small dosages were given the effect disappeared as soon as the injections were stopped. The injections were most effective during the period of declining lactation just previous to the last few weeks of the lactation record. At the extreme end of the lactation period the effect was hardly significant.

The conclusion to be drawn from this study is that while the thyroid plays an important part in the secretion of milk, it is not the most important factor. A.D.B.S.

Virgin Heifers Secrete Milk After Injection.

E. I. Evans. (1934). *U.S.D.A. Year Book*, 360-3.

Careful investigation has shown that pregnancy is not necessary for the full development of the mammary gland and milk secretion, but that by injection of the proper materials virgin animals—male as well as female—can be made to elaborate and secrete milk. It appears that the hormone theelin is responsible for the extension of the duct system, and that this hormone, together with the corpusluteum hormone, stimulates

complete mammary growth. It is here that the stimulus produced by the anterior lobe of the pituitary gland (a small gland about the size of a hazelnut lying at the base of the brain) comes into play.

For some time the investigators of the United States Bureau of Dairy Industry were under the impression that their preparations of this lactation stimulating hormone might be acting only as a stimulant to the animal's own pituitary. Recent experiments indicate that such is not the case. The point was settled by experimental surgical removal of a female dog's pituitary gland. The dog recovered from the operation, and in twenty-four hours was normal in every respect. Subsequent injection of the hormone caused copious milk secretion. As a result of this test it is supposed that the hormone is stimulating the mammary gland directly.

Many of the results were done with small animals and goats. But in an experiment with a virgin Jersey heifer the investigators were able to maintain an average of 15-18 lbs. of milk daily for several months after they had ceased giving the injection. According to their pedigrees certain of the experimental cows of the Bureau of Dairy Industry were thought to have received an inheritance for levels of high production. Their performance, however, was disappointing. Accordingly, these cows were injected with extracts of the anterior pituitary. In some cases production increased from 25-50 per cent. above the levels maintained immediately before injections were given. But these higher levels of production were not maintained after the injections were discontinued. Failure of the anterior pituitary to secrete proper amounts of its lactation-stimulating hormone is not the only cause for failure of higher production. It is, however, a major cause, and where it is lacking artificial injection can do the trick.

It only remains to be added that the expense of producing this hormone puts the possibility of its practical use right out of the question.

A.D.B.S.

SOILS AND MANURES.

Abstractor:

Professor T. W. Fagan, M.A., University College, Aberystwyth.

Soils; Their origin, constitution and classification. An Introduction to Pedology.

Gilbert Wooding Robinson, M.A. London: Thomas Murby & Co. (1936), pp. 432. Price 20/-.

The appearance of the first edition of this book in 1932 was warmly welcomed by agricultural chemists and especially by those who were familiar with the author's work on soil problems. The demand for a second edition within such a short time will therefore occasion no surprise as the book so obviously filled a long felt want.

Soil chemists are indebted to Professor Robinson and his colleagues for many of the recognised methods that to-day are in general use in most laboratories where soil analyses are conducted. His book affords them and others interested in soil problems the opportunity of reviewing his many valuable original contributions to soil science in relation to the fundamental problems that gave rise to them. The text throughout

the second edition has been revised, large portions requiring amendment in view of recent advances having been re-written, more especially the chapters dealing with Pedogenic processes, clay complex, base exchange and water relationship of soils and soil classification. The book has been enlarged by some sixty pages, from which it will be seen that a considerable amount of new material has been included. The chapters dealing with soil groups and soil geography have been added to and amplified.

It should be emphasised that the book makes a much wider appeal than to the agricultural chemist and soil specialist. The author's treatment of the subject is more especially designed for those interested in the soil as an object of study in itself, and is written in a manner which is more philosophical than technical.

The book, apart from its value to the student proceeding to a higher degree in soil science, cannot fail to be of great interest to students of geography, geology and botany, and to those interested in that branch of biology dealing with the habits and mode of life of living organisms in relation to their surroundings.

In this book such students will find illuminating chapters of absorbing interest closely related to their own subject. The publication in a word contains a great deal of information that is not to be found in any other book published in this country, and has been written by one who is a master of his subject. T.W.F.

AGRICULTURAL BOOKS, 1935.

The following list, prepared by the staff of the National Library of Wales, is a selection of the more important books on the science and practice of agriculture published during the year 1935, together with a few omitted from the list for 1934. The list supplements *The Hand List of Books on Agriculture* issued by the National Library, *third edition*, 1926, copies of which can be obtained on application to the Librarian, The National Library of Wales, Aberystwyth.

BAKER, F. S. Theory and practice of silviculture. New York: McGraw-Hill, 1934. pp. xiv, 502. ill., diags., bibl. $5.00

BEZEMER, T. J. Dictionary of terms relating to agriculture, horticulture, forestry, cattle breeding, dairy industry and apiculture in English, French, German and Dutch. London: Allen & Unwin, 1934. pp. [x, 1070] ... ... 25s. 0d.

BLAKE, A. J. JEX-, *Editor*. Gardening in East Africa . . . By members of the Kenya Horticultural Society and of the Kenya and Uganda Civil Services. London: Longmans, Green, 1934. pp. xvi, 330. col. front., col. pls. ... ... 12s. 6d.

BLOUNT, W. P. Sexing day-old chicks: a treatise on sex detection in pure and cross-bred chicks. London: Poultry World, Ltd., 1934. pp. [vi], 54. ill., diags. ... ... 2s. 6d.

BOWDIDGE, E. The Soya bean: its history, cultivation (in England) and uses. Oxford Univ. Press, 1935. pp. xiv, 84. pls. ... ... 6s. 0d.

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